DOCUMENT RESUME

ED 095 868 IR 001 048

AUTHOR	Zunde, Pranas
TITLE	Scientific and Technical Information Transfer for Education (STITE). Research Report No. 2.
INSTITUTION	Georgia Inst. of Tech., Atlanta. School of Information and Computer Science.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	Dec 73
NOTE	73p.; For related documents see IR 001 047 and 049
EDRS PRICE	MF-$0.75 HC-$3.15 PLUS POSTAGE
DESCRIPTORS	Algorithms; Computer Assisted Instruction; Indexing; Information Centers; Information Dissemination; *Information Needs; Information Processing; Information Retrieval; Information Storage; *Information Systems; Information Utilization; Literature Reviews; Mathematical Logic; *Science Education; *Sciences; *Technology
IDENTIFIERS	Scientific Technical Information Transfer for ED; *STITE

ABSTRACT

STITE (Scientific and Technical Information Transfer for Education) is basically a system to interface between science information and the science learner. As such STITE acts as a link between STIC (Science and Technology Infromation Centers) and LIS (Learning Information Systems). In this second progress report the internal knowledge of STITE is the main focus. Discussed are the algorithms, tree structures, descriptors, concepts, and representations considered part of STITE. Included in this report is a literature survey on different parts of LIS. (See also IR 001 047 and IR 001 049.) (WH)

RESEARCH REPORT

SCIENTIFIC AND TECHNICAL INFORMATION TRANSFER FOR EDUCATION (STITE)

Pranas Zunde
Project Director

December, 1973

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

SCIENTIFIC AND TECHNICAL INFORMATION TRANSFER FOR EDUCATION

(STITE)

Second progress report on research performed at the School of Information and Computer Science, Georgia Institute of Technology, Atlanta, Georgia, under National Science Foundation Grant No. GN-36114.

Pranas Zunde
Project Director

December, 1973

ACKNOWLEDGMENTS

The work described in this report constitutes essentially the second explorative phase of the project, during which certain categories of specific tasks were identified and analyzed. Participation of Dr. Miroslav Valach, Professor of Information and Computer Science, Mrs. Dorothy S. Hughes, Research Analyst and Librarian, and Mr. N. V. Subramanian, Graduate Research Assistant, in this phase of the study is gratefully acknowledged. They appear as authors or co-authors of the portion of this report to which they made major contributions.

TABLE OF CONTENTS

PART ONE

MAJOR FUNCTIONS OF THE STITE SYSTEM

PART ONE

MAJOR FUNCTIONS OF THE STITE SYSTEM

Pranas Zunde and N. V. Subramanian

I. INTRODUCTION

One of the major areas of concentration of research effort was the identification and specification of the types of potential outputs of the STITE system which would be helpful to educators in preparing, developing, and maintaining teaching materials and devices of all sorts. Seventeen classes of such hypothetical outputs were identified; in the sequel. a class of outputs of the STITE system. associated with some particular function, is referred to as task. For each of these (as yet hypothetical) tasks, inputs are required for implementing the particular task, type of system's output, options available to educators in modifying tasks and data base requirements for a particular task. A tentative study of overall file organization was also made. All these specifications were prepared primarily with graph theory as the experimental subject area in mind.

II. LIST OF TASKS

1. Task No. 1. - Preparation of Course Outline

Input - A sequence of major topics that are intended to be covered by an educator in a specific course. Query for the course outline.

Output - A detailed course outline, giving all the available sub-topics under each topic mentioned in the input.

Option - The educator can either choose all the sub-topics or delete some of them. Under a specified major topic, the educator keeps in mind the specific course that he wishes to offer to the student and the objectives of that course.

Data Base Requirements - A table which contains all the sub-topics under each major topic and possibly in a sequence as per the relationship between the individual major topics.

2. Task No. 2. - Preparation of Narrative Presentations.

Input - Sub-topics and query for the narrative presentations.

Output - Set of all relevant theorems.
- Proofs of above theorems, giving all the axioms and the theorems used in the proof of the theorem under consideration.
- Presentation of graphical data in support of the above theorems.
- Explication of concepts associated with each sub-topic chosen by the educators.

Option - Educators have the option of selecting some of the theorems and concepts, depending on the level of difficulty of the course they are planning.

Data Base Requirements - All theorems under each sub-topic with proofs. Graphical data explicating the theorems (if any)
- A glossary of all concepts and supporting figures or formulas, if any.

3. Task No. 3. - Presentation of illustrative examples (graphic data, or a table or a numerical example) for theorems. Illustrative examples for concepts. Here the examples need to be listed under each sub-topic, each theorem, and each concept.

Input - Sub-topic, theorem number, or the key word for the theorem and the code number of the concept. Query for the illustrative examples.

Output - Illustrative examples on a printer, graphical data on a display unit, numerical examples on a CRT.

Option - The educator, on previewing the problems on CRT or any other display unit, can choose some of the examples to be printed out in a printer. A CALCOM plotter can be coupled if a graph has to be plotted in the example under consideration.

Data Base Requirements - All the illustrative examples, including numerical examples, graphical data, tables etc., with the appropriate key word descriptions of the theorems. Concepts and sub-topics.

4. Task No. 4. - Presentation of Problems Under Each Sub-topic or Under Each Theorem Sub-topic or Under Each Concept in a Sub-topic.

Input - Sub-topic, theorem number or key word for the theorem and the code number of the concept. Query for the problems which are direct application of the concepts. Query for the solutions of the chosen problems, on identifying the problem number.

Output - The problem on a printer or on a CRT, along with the number which is a measure of the level of difficulty of the problems determined and entered into the system by the subject expert who works with system development staff.

Option - The educator community can choose the problems according to the level of difficulty desired by the educator community or according to the IQ index of the students in the case of individualized programmed instruction.

Data Base Requirements - A set of problems with level of difficulty markers referenced with appropriate key word descriptors and cross linked with the descriptors of the theorems, concepts and sub-topics.

5. Task No. 5. - Presentation of Bibliography Under Each Topic or Sub-Topic

Input - Document specifications in a descriptor language having the descriptors of sub-topic or concept words in the chosen topic. Query for references.

Output - A set of references under the heading of each sub-topic or major topic, depending on the design of programs.

Option - The educator can retrieve the set of references on a CRT and scan it before he gets a hard copy of the same, or in case of microfiche storage or references, the educator can retrieve the appropriate microfiche card and, after reading the relevant references on a microfiche reader, receive a hard copy of the same.

Data Base Requirements - Depending on the storage mechanism (whether on tape or on microfiche) the set of references with the document specifications should be stored with the links to appropriate abstracts.

6. Task No. 6. - Presentation of Application of Theoretical Concepts in Each Major Topic.

Input - The concept codes and the theorem numbers. Query for application of the theoretical concepts in each major topic.

Output - The educator gets a visual display of the titles of all applications on store under a given topic. Some of the applications are chosen and are subsequently printed on a line printer.

Data Base Requirements - A disk has all the applications of the theoretical concept codes or theorem numbers or the descriptors of a major topic.

These real world application, in turn, may have numerical examples or graphical data as illustrations of specific applications in certain science fields. Therefore this task is linked with task No. 3, and may share the same files being utilized for task No. 3.

7. <u>Task No. 7.</u> - <u>Presentation of Case Studies</u> (i.e. citation of real world cases and analysis of the same from the point of view of some of the theoretical concepts explicated in the earlier tasks. For example, in the field of graph theory they might include engineering applications, human sciences applications, application in physical sciences, operations research, etc.)

<u>Input</u> - Here the titles of some of the real world cases are presented. Query for an analysis of the presented field from the point of view of the theoretical concepts in a subject.

<u>Output</u> - Depending on the relational entailment structure of the concepts and the applications, the relationships between the chosen case and the concepts in the chosen subject area are pointed out on a printer.

<u>Data Base Requirements</u> - A relational structure of the basic concepts in the chosen subject area and the applications in the real world should be created on the data base. A parser program might eventually be developed which creates the syntactic structure of the basic concepts and their links with the applications in the real world.

8. <u>Task No. 8.</u> - <u>Presentation of Abstracts of Specific Documents</u>

<u>Input</u> - The keywords for the desired reference or the reference numbers, presented in task No. 5, as output. Query for the abstract of the same.

<u>Output</u> - The abstract of the references in the query are printed on a line printer.

<u>Data Base Requirements</u> - Magnetic tapes with the abstracts of all the reference numbers. It is also proposed to include in the entailment structure the relationships between abstracts in a common relation with a concept or a theorem or a sub-topic. It would be

desirable to have built into the data base the capability of retrieving all related abstracts upon the presentation of the reference number of one specific abstract.

9. Task No. 9. - Presentation of the State-of-the-Art or of Abstracts Covering a Specified Period.

Input - Give specifications of time period such as 6 months, 1 year, or 2 years. Query for the abstracts of all the documents published in the specified period of time.

Output - The abstracts of all the documents published in the specified period of time are printed on a line printer.

Data Base Requirements - This task requires that all the abstracts with their publication date be stored. In addition the system should have the processing features necessary to do the desired task. In short, all the above tasks require a considerable amount of programming for these specific task.

10. Task No. 10 - Presentation of Historical Development of a Specific Discipline (i.e. retrieval by date of publication so that latest is retrieved last.)

Input - Query for the historical development of a specific subject discipline, with a specification of time such as past ten years.

Output - Retrieval of abstracts of all the relevant documents in order of date of publication, with latest first and oldest last.

Data Base Requirements - This task does not impose additional file structures, but it does require additional application programs or stored programs which search the data base on the basis of date of publication. This has to be accomplished in several passes.

During the first pass, the processor keeps a record of the latest publication so far searched and, on searching the entire file, puts a marker '1' on the latest publication. Then it executes the same program again, searching only the no-marked abstracts. The machine carries on this till it finds all the abstracts published in the specified period of time.

11. Task No. 11. - Preparation of Quizzes of Tests for Students.

Input, Output - An interactive program is to be developed to accomplish this task. On keying in the level of difficulty markers, the educator gets a display of all problems and questions with the specified level of difficulty markers. Then he chooses some of the problems and questions according to the length and type of test he desires to give to his students. Upon identifying the selected problems with appropriate descriptors, the educator gets a print-out of his model test paper.

Another less flexible alternative might be the programming of actual tests. Here pre-structured test papers can be put on the data-base by a team of subject experts. This should be accessible by authorized personnel and educators only. Test papers can then be retrieved by the educators for the purpose of giving a quiz or an exam to students.

12. Task No. 12. - Presentation of a Set of Relevant Questions On Topics or Sub-Topics.

Input - The keywords for the topic or sub-topic. Query for descriptive type questions and problem type.

Output - This task shares a common file with task No. 11. A list of questions under the heading of the specified topic or sub-topic.

Option - The educator can choose the questions to be printed out on the printer.

Data Base Requirements - No additional file requirements for this specific task. A special application program is required to be developed for this task.

13. Task No. 13 - Identification of New Concepts and Preparation of Updated Materials for a Specific Topic.

Input - Query for updated materials for the narrative presentations.

Output - New concepts, new theorems to be included in certain sub-topics. The new concepts appear under the appropriate sub-topics on the print-out.

Data Base Requirements - A program package which parses the abstracts, compares with the concept descriptors in store, identifies the new concepts and forms the basis of the link of the abstracts with the sub-topics, determines the update materials under a specific sub-topic.

14. Task No. 14 - Retrieval of All Abstracts Related to a Specific Abstract.

Input - The reference number of the abstract. Query for all the relevant abstracts.

Output - All the relevant abstracts (based on the links between abstracts to be established in the entailment structure) are printed on a line printer.

Data Base Requirements - No additional file requirements, but it is necessary to develop additional features in the appropriate application programs. This task mainly depends on the entailment structure of the abstracts in a given subject discipline.

15. Task No. 15 - Presentation of Definitions of Concepts. (i.e., given an explanation or definition of a concept present the explanations or definitions of all the concepts required for the explanation of the specific concept under consideration.)

Input - Concept code number in the glossary file. Query for all the relevant concepts.

Output - All the relevant concepts or definitions based on the links between the concepts (to be established in the entailment structure), are printed out on a line printer.

Data Base Requirements - No additional file requirements. Requires the development of additional features in the necessary application programs. This task mainly depends on the entailment structure of the concepts in the glossary file of a given subject discipline.

16. Task No. 16 - Presentation of Subjects, With References and Abstracts for Assignments for Students.

Input - Major topic descriptors. Query for assignments or term papers for students.

Output - Titles for term papers with a set of references as a guide to the students.

Data Base Requirements - A separate magnetic tape file with all possible term paper titles, along with the appropriate sets of references.

17. Task No. 17 - Presentation of a Measure of Newness of a Particular Concept. (Given a statement or concept as input, provide a measure of newness of the concept on processing the descriptors or the keywords in the new concept, comparing it with the descriptors of the concepts in store.)

Input - A statement or a definition of a new concept from an abstract. Query for the newness measure of the concept.

Output - A statement giving a measure of the newness of the concept.

Data Base Requirements - An application program which compares the descriptors of the new concept with the descriptors of the basic concepts on store and with the descriptors of the concepts added so far from the abstracts. A relative measure of the matching of the two can be calculated by the machine according to some preset standards, and the result appears on the CRT.

III. DESCRIPTION OF THE FILE ORGANIZATION

Following is a rudimentary outline of the file organization of the STITE system required for performing the above described tasks.

1. Task No. 1. - access to file numbers 2 and 3 no processing required.
2. Task No. 2 - accesses to file 7, 8 and 9 no processing required.
3. Task No. 3 - accesses to file 10 no processing required.
4. Task No. 4. - accesses to file 6 no processing required.
5. Task No. 5. - accesses to file 11 no processing required.
6. Task No. 6. - accesses to file 1 no processing required.
7. Task No. 7. - accesses to file 5 no processing required.
8. Task No. 8. - accesses to file 12 no processing required.
9. Task No. 9. - accesses to file 12 processing required.
10. Task No. 10. - accesses to file 12 processing required.
11. Task No. 11. - accesses to file 13 no processing required.
12. Task No. 12. - accesses file 13 no processing required.

13. Task No. 13. - accesses to file 12
processing required.

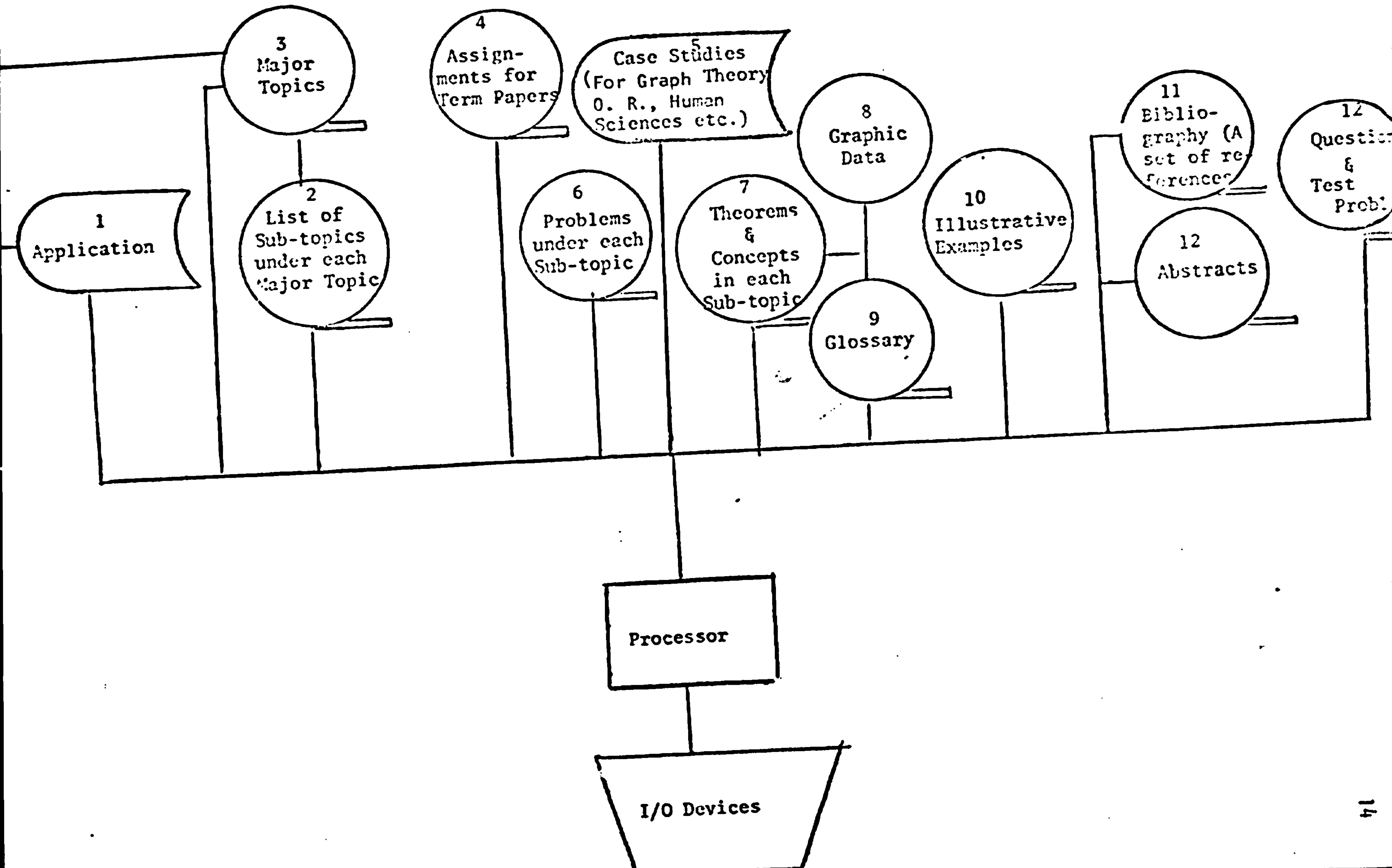
14. Task No. 14. - accesses to file 12
processing required.

15. Task No. 15. - accesses to file 9
processing required.

16. Task No. 16. - accesses to file 4
no processing required.

17. Task No. 17. - accesses to file 9
processing required.

File Organization for the Pilot STITE System



PART TWO

THE INTERNAL KNOWLEDGE OF STATE

THE INTERNAL KNOWLEDGE OF STITE

Dr. Miroslav Valach

I. INTRODUCTION

The internal knowledge of STITE integrates information necessary for the processing of given requests into a multipurpose structure designed for facilitating both retrieval and processing data contained either internally in STITE or externally in the centers to which STITE has access.

Among the purpose for its creation and its highly structured representation in STITE are:

1. To facilitate identification of mutually related elements (documents, keywords, topics, files, descriptors, authors, concepts, etc.), where the relationship between the elements can be specified and created as a consequence of dynamic growth and use of the system.

2. To provide a data-base for an on-line question-answering system that enables the user to utilize STITE for interactive presentation of refined views on given areas and for links to existing literature or other documents by giving, either specifically or generally, the desired point of view.

3. To locate information relevant to the request, be it in internal or external data bases. One of the important parts of the structure is the linking of items with bibliographic and other documents or sections of documents. The basis for this is in the use of general thesauruses or indexes and glossaries contained in individual (or selected) documents.

4. To provide for services to educators for the structuring of courses, for specific relationships among given topics, concepts, and documents, in which internal knowledge plays a substantial role in adequate treatment of the request. The more automated and demanding the process, the more important is the use of internal knowledge.

The attractiveness of highly-structured internal knowledge lies in the fact that once the effort to creat it has been undertaken, it provides the basis for dynamic, automatic growth of the system and provides a uniform base for manifold use of the knowledge; for the majority of the requests, while differing in their specific requirements, still refer to the common internal knowledge.

Processing of unspecified tasks, for search by STITE or by the user, in a way that allows the user to shape or create his own approaches in cooperation with STITE is another feature of highly structured internal knowledge.

II. ALGORITHMS FOR THE MANIPULATION OF THE INTERNAL KNOWLEDGE OF STITE

Analysis of the topics considered for use with STITE shows that there are primarily four elements of a response to a request.

1. Internal Knowledge

Internal knowledge of some kind that must be questioned or used as a guide for processing the request is necessary in STITE. The level of sophistication of the internal knowledge of STITE will parallel the level of sophistication of the reaction to the request. Therefore, it is the internal knowledge, its structuring and the technique of its use that will primarily determine the efficiency and the reactional characteristics of STITE. Internal knowledge will be a common base for both automated request processing and interactive request processing.

2. A Special List of Items Linked to the Internal or External Knowledge of STITE.

A list of the items that are to be found is given specifically by name or descriptor or a more general term that is more specifically defined by the process. The basis for such activity is the internal knowledge of STITE that is linked to specific items contained in the request or identified indirectly where the special identification is again made by use of the internal knowledge.

3. Programs

Programs will manipulate internal knowledge and items linked to internal knowledge and that are of general character, such as linking existing knowledge by a new descriptor, and finding neighbors or areas of a certain node (concept, document, keyword, etc.). The programs are in one way or another used for the benefit of most requests in adequate preparation (creation and manipulation) of the internal knowledge.

One typical such program is an extraction of certain parts of internal knowledge for the purpose of refined structuring in isolation from the whole structure, providing for "a refined interface structure" with a wide data base.

4. Special Programs (subprograms, Subroutines) Specifically Written For a Particular Request.

Such programs that are inevitable in a system like STITE form a library of STITE programs, special capabilities that are the core of the dynamic development of the system.

Thus there are two bases of the growing "intelligence" of STITE:

1. growing library of programs
2. growing internal data base, its structuring and use as internal knowledge.

AL1 Transformation of a content (book content, document content) into a content tree structure.

AL1 transforms the table of contents TC of a document into a tree structure (See tree structure for reasons and use). If the input of the content is manual, organizational markers can be agreed on so that AL1 can easily recognize chapters, paragraphs, examples, introduction, and glossaries. If input from an existing tape comprises the markers, markers should be included into descriptor file D_L, and manipulation for structuring should be derived from it so that AL1 retains its generality.

If, on the other hand, the tape does not have organizational markers, a special recognition subroutine must be attached for organizational markers. Otherwise interactive manipulation, (using existing editing programs for a given computer) can be utilized to review the tape and establish the markers.

It is not anticipated that all documents will be processed by AL1, especially if the document does not contain the markers or is not in the form for automated input.

On the other hand, there are basic books or articles for certain areas of knowledge that should be part of a detailed structuring for the creation of an adequate internal knowledge of STITE. In such a case, all efforts should be made to input (manually) the table of contents or an even more detailed structure into STITE.

It is proposed that in each area of knowledge there be an expert responsible for the content of the internal knowledge of STITE in that area. This expert will monitor not only external enrichment of the area but also the formation of an internal cluster of knowledge for that particular area from the internal resources of STITE and eventually from the statistics of the requests in that area.

<u>AL2</u> Transformation of concept structure into concept tree structure.

Reasons and advantages for such transformation have been discussed elsewhere. How feasible it will be to make this transformation by a computer algorithm still remains to be seen. To create AL2 for general input data seems to be behind the state of the art today. However, it is acceptable in the early stages of STITE that the transformation be made by human beings or that it be extracted automatically from existing descriptions where the existing organizational structure of the presentation of the concepts in the corresponding document will be used as a basis for the tree structure. Pask's studies for CASTE system show that the creation of a large concept structure requires human effort. There have been no attempts to transform such a structure into tree structure automatically. The closest approximation to this type of work is automated abstracting which, at this stage, does not have satisfactory results for application for STITE.

<u>AL3</u> Transformation of the tree structure into linear sequence.

Provided that there is given a format for each level by which the nodes of the level are to be ordered, AL3 is a relatively simple algorithm. It is to be expected that the representation of the tree structure in STITE will have special character due to the n-ring approach, and therefore AL3 will have to be adjusted to it. However, no special problems are forseen for writing AL3 as a program.

AL4 Formation of a ring for a given descriptor.

Two versions are required, A and B.

A-version Nodes of the structure have d-descriptor in P form, transformation RT is required to create R-form. (See VI, Aspect 2)

B-version R-form into P form with d-descriptor.

The program itself is a short program with, however, a sophisticated way of string processing techniques. It requires some experience in string processing and adaption of current techniques to multi-link versions.

It is to be expected that after testing, modifications will be required. Also additional modification or even substantial revision is likely to come after larger structures come into use. The algorithm will necessarily be dependent on the linking technique, as well as on the total approach to the structural representation of internal knowledge. Any change will very likely affect AL4, which is to be anticipated in advance as a necessary step in research and development of STITE.

Experiments and evaluations of effectiveness will have to be conducted gradually during different phases of implementation, especially under the condition of a larger structure.

One of the critical spots will occur when the larger structure must be processed for extraction and/or isolation of a certain area in which some of the links with the source-data-base is to be maintained while others are to be interrupted. (Transfer made at higher levels may not require interruption while transferred lower levels of the structure will.)

AL5 Formation of the tree structure from given descriptors.

AL5 occurs in case of a course outline where various units of knowledge are to be grouped into smaller and larger groups and ordered within each of them.

It requires that some format be given, that the format contain given descriptors, and that items of the request be associated with the descriptors of the format.

Some clarification in the area of association of descriptors with the content will still be required. In the area of course outline, where topics and subtopics, exams, number of lectures, and other organizational groupings seem to be clearly identified, it does not seem that AL5 will have substantial problems. However, automated orderings or groupings of the topic require a closer look.

AL6 Location of given subtopics in the data base.

To find subtopics in an external data base that does not have detailed links with IKN of STITE involves using conventional search techniques which are available at the particular site in question. AL6 in this case just transfers the request to the external source and receives in resolution level the answers that it cannot control.

In case of the use of IKN (internal knowledge), there are three ways to find the subtopic.

1. by the descriptor of the subtopic - following corresponding rings, branching in each node, looking for neighbors
2. by associations created in the sources of glossary (neighborhood or other relation)
3. by associations created unconventionally (ad hoc for particular purpose in D_L)

In all three cases the basic question is to locate neighbors of nodes located along the same ring.

No special problems are anticipated in programming techniques. However, how such a search will be controlled must be determined and how many neighbors to look for, how deep to go in neighborhood structure, and how to identify relevancy must be decided. AL6 still requires close attention from the algorithm point of view.

AL7 Formation of a cluster from given set of subtopics

AL7 means that there are missing subtopics that have to be both identified and located to complete the cluster. Control of such a process has to have indicated more specifically (or as options chosen under some rules) what it means to form a cluster; i.e., chain like, fill everything in, subcluster with all connections in what resolution level.

Specifications for AL7 require further study. It is likely that some experimental type of research will be necessary, not only to formalize the approach, but also for practical aspects of the problem.

AL8 Location of documents that contain a given topic.

If the topic is part of IKN, it will be found in refined resolution level specifying the location very precisely on the sub-document level. Generally this should not be any problem since it is assumed that links to the documentation exist or are formed whenever a new document is included or new structures are formed.

No special requirements for AL8 are forseen. The use of the thesaurus, glossary, and D_L - structure will be much the same as in other algorithms. AL8 may be subject to modification similar to AL4, but in a lesser degree.

AL9 Location of documents that contain relevant theorems on a given topic.

This question could be very difficult if relevancy is to be determined in some other way than by a descriptor of the theorem. The question of theorem descriptors (different from key-words) is already difficult, especially if the theorem is given in relation to a theory or to another theorem of the theory and relevancy is meant as application of the theorem.

State of the art requires that either the descriptor of such a theorem be made manually or that the whole problem of AL9 be answered on an interactive basis.

If implemented interactively, the system can be very useful in retrieving theorems and/or related portions of the document if it has been structured in such details in IKN.

It is anticipated, however, that theorems are parts of glossaries or structures of documents containing necessary descriptors or clues. They can be traced automatically upon request or interactively to the heading of the paragraph, chapter, book, or author that contains the theorem.

AL10 Location of all pictures as given part of data base relevant to given topic.

Pictures can be traced by keywords or descriptor links to the headings of paragraphs and chapters or through the descriptions of the picture (text under the picture, linked to D_L). This algorithm requires still further consideration.

AL11 Parse out structures relevant to a given topic from a given glossary.

This problem is similar to AL7.

III. TREE STRUCTURE AS A BASIS FOR THE STRUCTURE OF STITE - INTERNAL KNOWLEDGE

The primary purpose of STITE is to be a mediator between existing data bases as the outside knowledge of STITE and a user-educator who is searching for relevant answers to requests in which merely retrieving a particular document would not be satisfactory. STITE therefore has to respect the existing structure of information as it occurs in our society. It can be, and many times is, regarded basically as a tree structure by the organization of the documents.

Top nodes of the tree structure are libraries and information centers. Each of them has lower nodes such as departments or document classification (typically tree structures by location, author, subject) where access to the infomation by any of the indexes is mediated by numeric or alphabetic search. The search is indeed a tree structured search. Even location of the document in shelves by topics again uses tree structure, each level having its own sub-levels.

It is proposed that the tree structure approach be used as a continuous process and extended below the level of document, i.e. that the internal organization of documents (books, articles, journals, abstracts, chapters, paragraphs) be regarded by STITE as a tree structure (which it in fact is in all documents) and that it also be represented as a tree structure for the internal use of STITE in its internal knowledge whenever convenient or necessary.

This approach will enable uniform processing of information in any level, regardless of its size, whether it be a group of books under the same topic in a higher level of organizational hierarchy or a special paragraph of a document or theorem in a book or sentence in the most refined level of the hierarchy.

The system will be able in this way to process information on mutually different "levels of resolution" without the necessity of adjustment of the algorithms to each level.

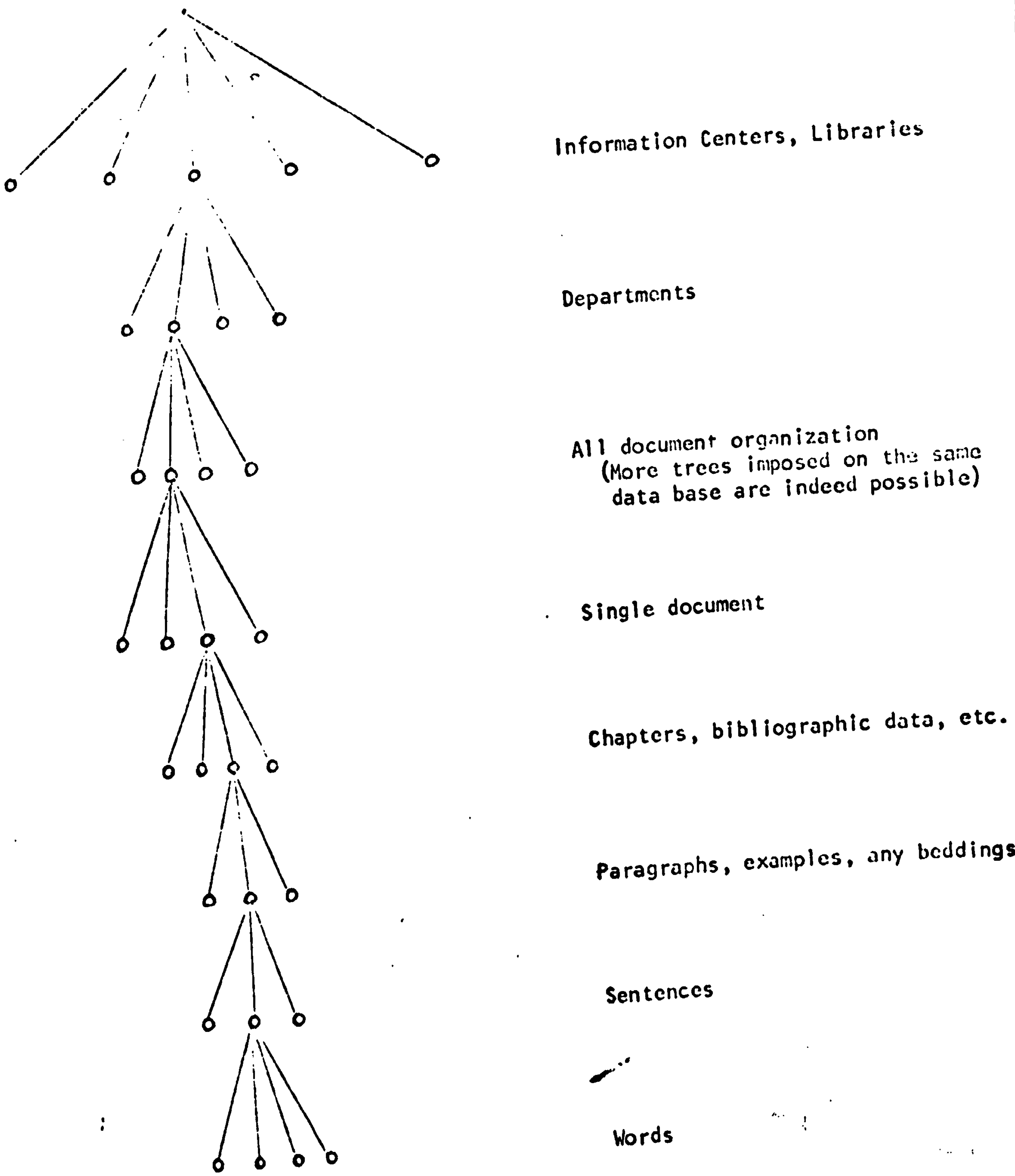

Information Centers, Libraries
Departments
All document organization
(More trees imposed on the same data base are indeed possible)
Single document
Chapters, bibliographic data, etc.
Paragraphs, examples, any beddings
Sentences
Words

Fig. 2

It is true that whenever a concept or unit of knowledge is to be presented in the form of natural language, the presentation is first transformed into tree structure and then linearized by formation of paper, book, etc.

It would be ideal to represent all units of knowledge, associated thoughts, concepts, or other information groups in the form of a tree structure. One such approach is offered by the concept of system as being composed of elements and relations. If concepts or units of knowledge could be regarded as systems of the same kind, it would certainly be possible to represent them meaningfully as tree structures. Additional attention will have to be paid in the future to this question.

One of the biggest advantages of tree-structure representation is that it provides for very effective manipulation of information at a given level without destroying upper or lower level organization, e.g., chapters can be reordered without touching paragraphs, merely by changing the linking among chapters. Everything else remains untouched.

It allows reordering of levels, insertions or deletions of the nodes (with or without the whole structure in lower levels). It allows use of the same node with the same substructure (subtrees) in more than one organization or removal from the organization with the whole subcontent and placing it into another organization merely by changing the links leading to the node and out of the node, e.g., if a certain topic is prepared for a graph theory course and later it is decided that it will be presented also in the course for network design, all structure below the node can be transferred automatically by merely changing the linking of one node. In addition, all remaining links, such as a bibliography for concepts included in subnodes, linking of keywords, references to associated concepts, or glossary linking, remain untouched and are transferred automatically.

This is just one obvious example of the thrust in effective manipulation gained by the fact that the organization of the information in the internal knowledge of the system follows the accepted tree structure organization of existing documents.

The series of figures, Fig. 3 through 6 , show in concrete detail various levels of existing organizational hierarchies of information. The figures show the levels and attached descriptors (that can be either special for a given level or portion of the document or common for more than one document).

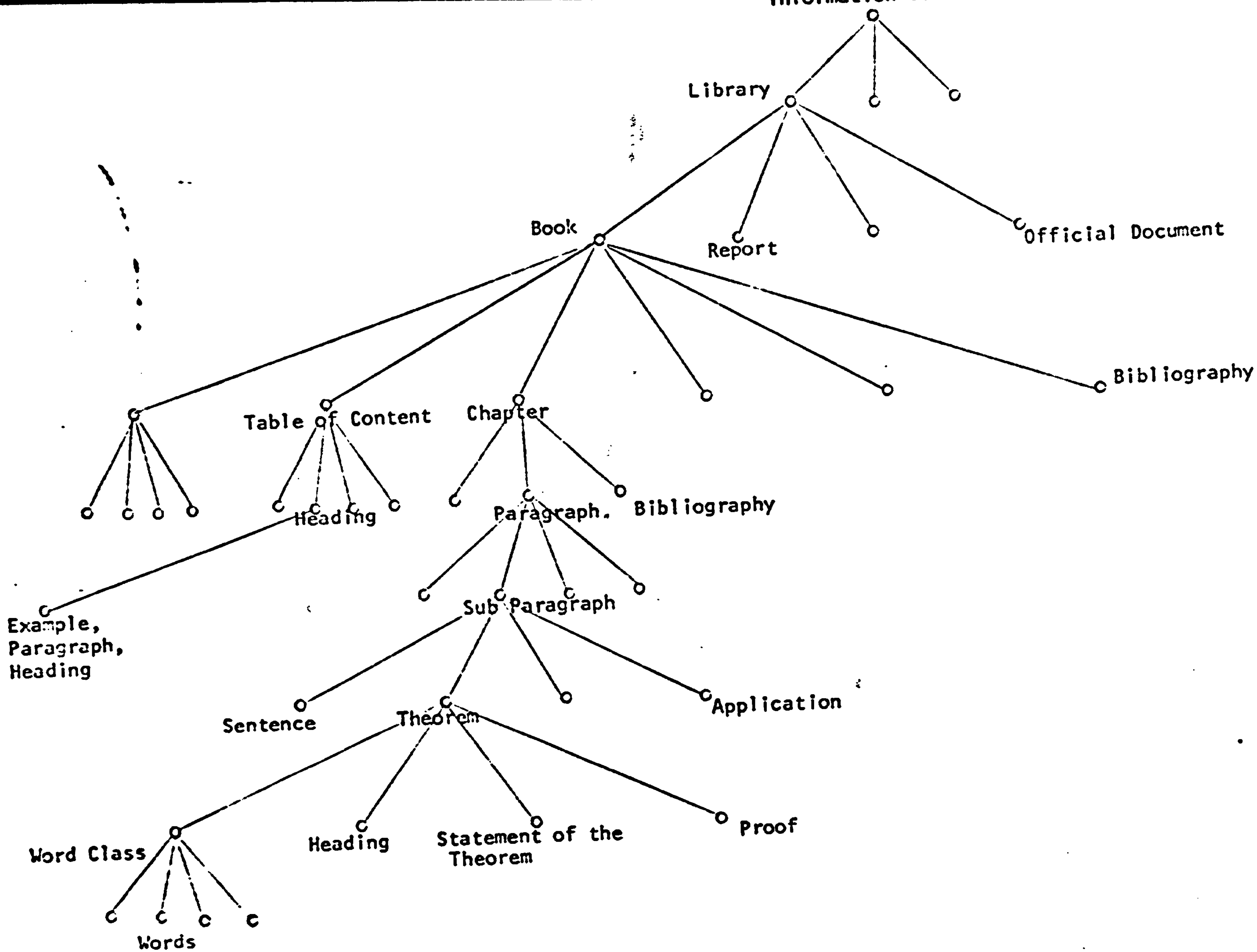

Library
Book
Report
Official Document
Bibliography
Table of Content
Chapter
Heading
Paragraph.
Bibliography
Example,
Paragraph,
Heading
Sub Paragraph
Sentence
Theorem
Application
Word Class
Heading
Statement of the
Theorem
Proof
Words

Fig. 3

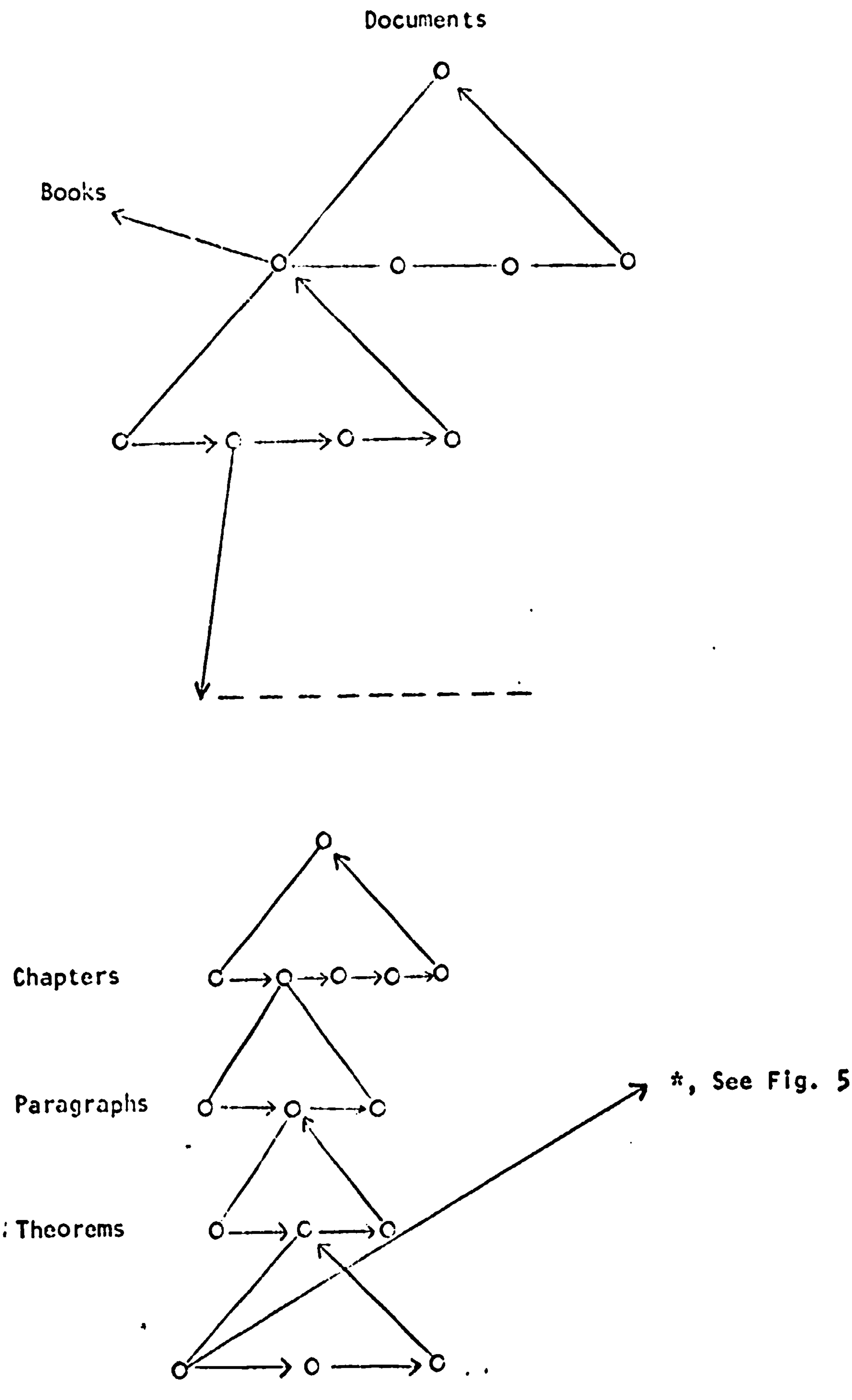


Fig. 4.

Storage Of And Reference To The Theorem 4-17

DATA BASE

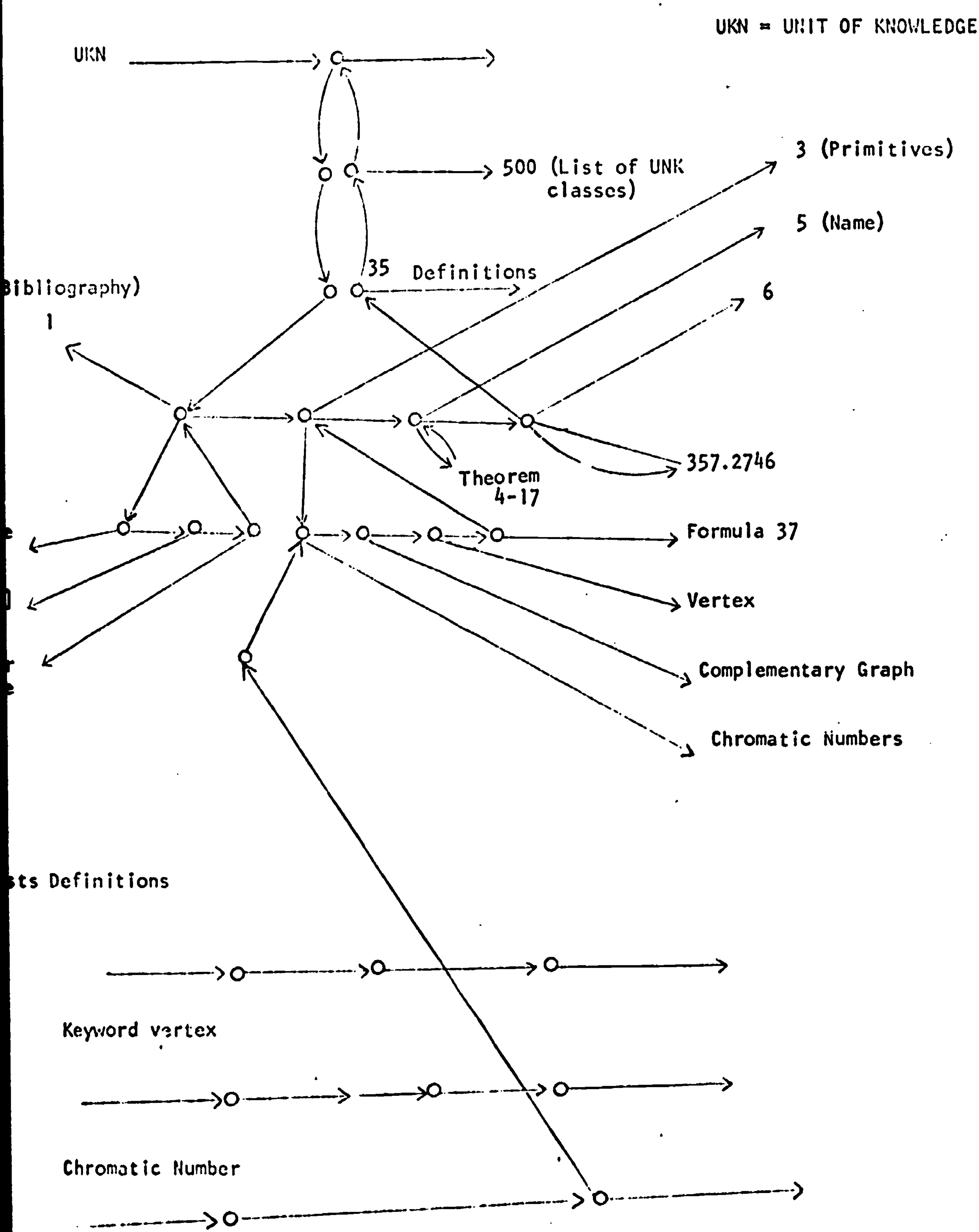
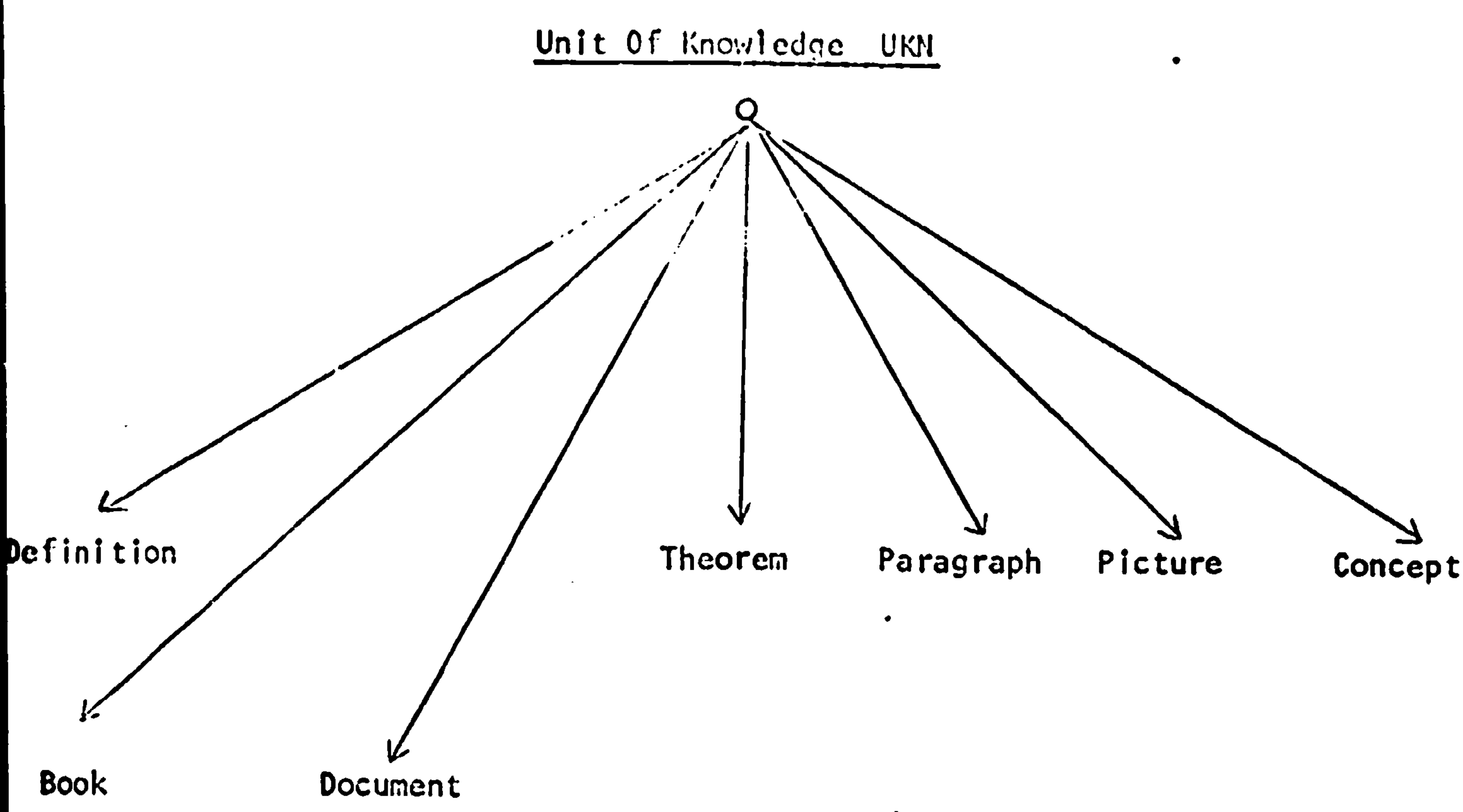


Fig. 5



500

35 Definition
36 Theorem
37 Paragraph
38 Picture
39 Concept
40 Book
41 Document

List of Classes of UKN

1. Where is it stored, bibliography
2. Difficulty measure
3. Primitives (elements)
4. Relations among elements
5. Name
   Language

6. Double decimal classification

Descriptors, definition of classes
- → for identification
- → for cataloging
- → . . . .

Fig. 6

IV. EXAMPLE: COURSE OUTLINE

Course outline is one of the typical requests of an educator; the response to the request is shown in Fig. 7. It can also be represented as a document that is a tree structure from the point of view of its organization. It differs from other documents by meaning (descriptors) of the nodes in which it is specific. However, any deletions, insertions, ordering, or other operations on the course outline do not differ from organizational operations on any other document and share the algorithms for the processing of the tree structure organization.

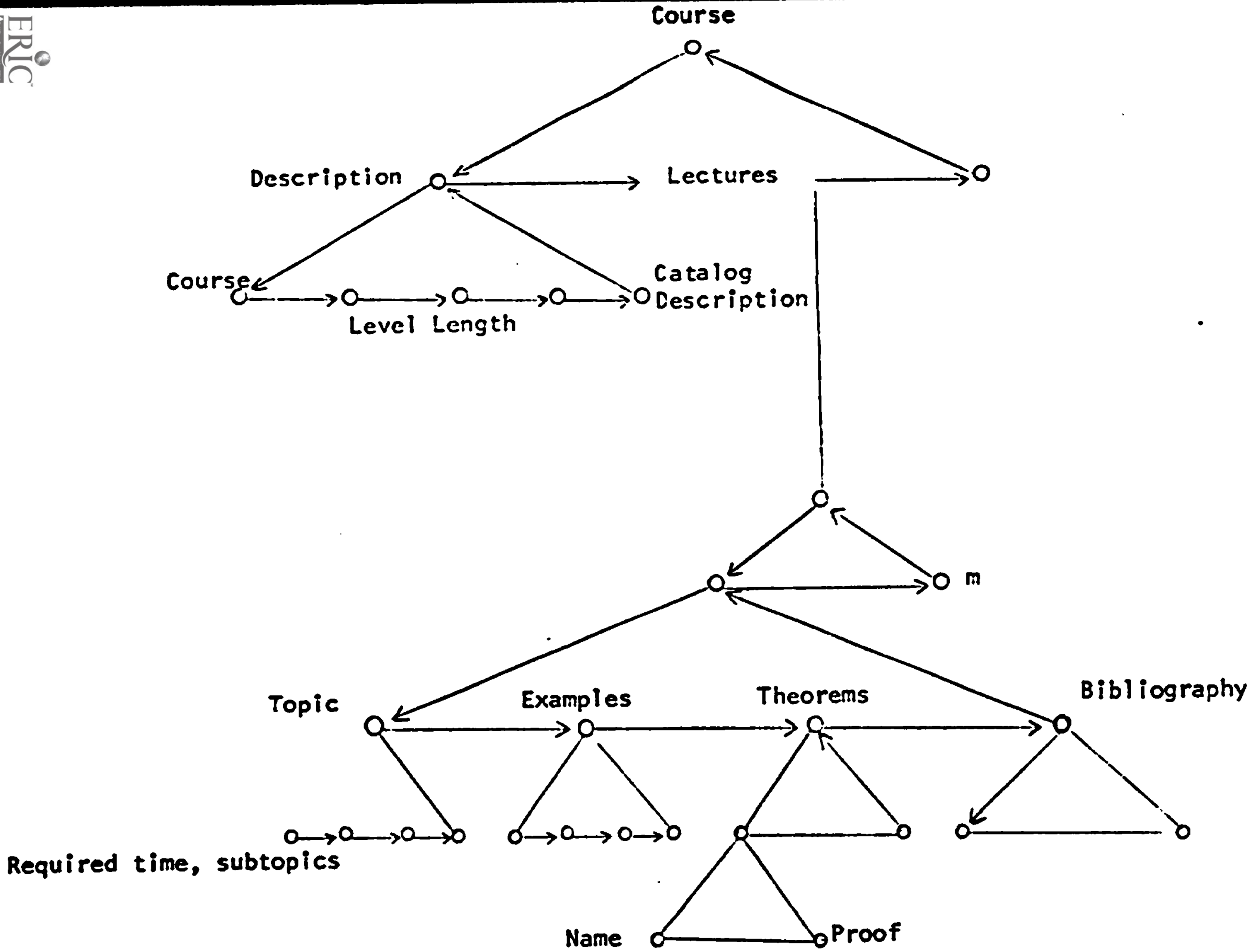
Course outline can therefore be looked at as an empty tree structure that is filled with pointers to the descriptors, concepts, modules, bibliographies, and examples from the request directly or from the internal knowledge under the guidance of the request.

As always is true about tree structure, the course outline need not be processed serially. Different nodes of the tree structure are first classified by the request, i.e., examples, definitions, concepts, surveys. The substructure for the node is then filled in independently on other parts of the tree. Proper hierarchy of the nodes is established and kept while the tree structure can be unfolded later as an ordered string of nodes.

Given tree structure represented by use of + and · as delineators for paraellel and serial nodes, then

$$a_1\ a_2\ (a_3 + a_4 a_5) + a_6\ (a_7 + a_8) + (a_9 + a_{10})\ a_{11}\ a_{12}$$

Permutations can be made on nodes $a_{10} \cdot \cdot \cdot \cdot a_{12}$ in operational level of the expression, independently of each level and sublevel in the same subtree. Permutations take into consideration precedence relationships established from the knowledge of combinations of concepts, shortest path criteria from tracing of missing links among requested concepts, etc. Also, suggestions from the user's request, preferences based on various statistics, experience, or other suggestions linked to the particular area of the knowledge can be taken into consideration.



Format for Course Outline

Fig. 7

V. ASPECTS AND EXAMPLES OF DESCRIPTORS

Descriptors are node classes of the nodes in the structure of internal knowledge. Let N be node of the structure S_{IKN}, then d will be the class (given by descriptor d) and dN class of the node N.

There are five aspects of d that need to be considered:

Aspect 1.

d is a class given by so called descriptor (D), where Dd is a descriptor of the class d. To assure high flexibility in formation of S_{IKN} and its effective use, Dd is an element of a list D_L (unique list of descriptors of S_{IKN} or special list with deliniated validity for restricted area). If a node is to be classified by d_D, it is always done by a pointer that points from N to D_L.

Aspect 2.

If it is desirable, and the same descriptor dK is used for more nodes, i.e.

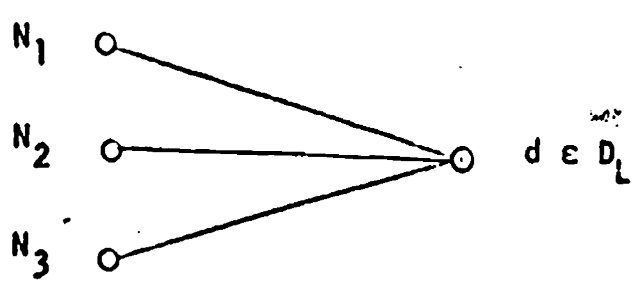
$$N_1 \neq N_2 \neq N_3 \; . \; . \; . \; . \; .$$

then nodes N_1, N_2, N_3 . . . are joined into a ring Rd then is in fact a file connecting all nodes of the same class in a cyclic-link with D_L.

Example: Case of desirable ring (file): descriptor d_1 - "coloring problem as a problem of graph theory. If

$$d_1 N_1 = d_2 N_2 \; . \; . \; . \; . = \; d, \; d \in D_L$$

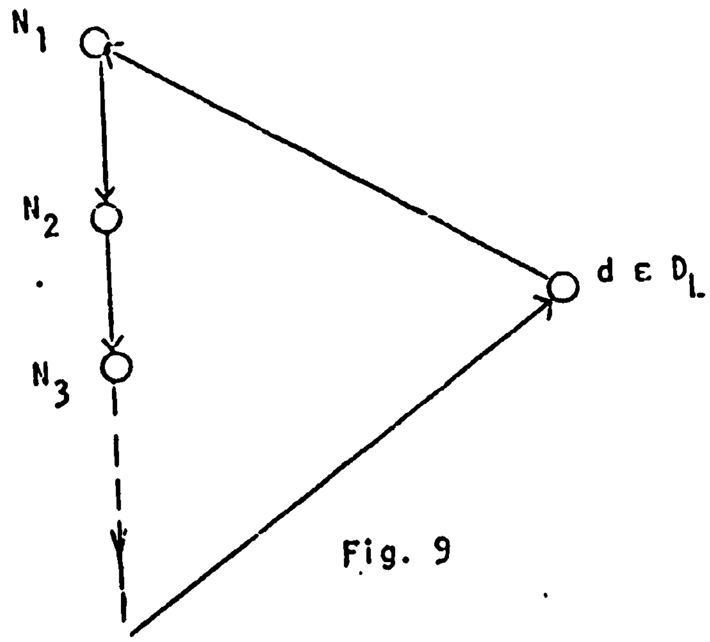
then pointers



(A1)

Fig. 8

are replaced by



(A2)

Fig. 9

With proposed double-ring concept, any node can participate in as many rings at the same time as is practical.

Symbolically, the forms A1 and A2 can be described respectively as

$$a \quad d_1 N_1 = d_2 N = \quad = d \in D_L \equiv P(N_1, N_2, d)$$

as points form P, and ring as $R(N_1, N_2, d)$. The operation RT that transforms P - form into F - form can be called "Ring - transformation" or RT. Then

$$R(N_1 N_2 \ . \ . \ . d) \equiv RT(P \quad (N_1 N_2 \ . \ . \ . d)$$

RT operation transforms one-way pointers into ordered files in which not only the class of the node can be accessed, but also, given a class, all nodes having the class can be accessed too.

For reasons of both-way effectiveness R and P forms should be combined for practical purposes. If the file is too big, it is time consuming to find the class. PR - form is called a combination in which such ring R is formed that each nth node contains a pointer to d, as illustrated below

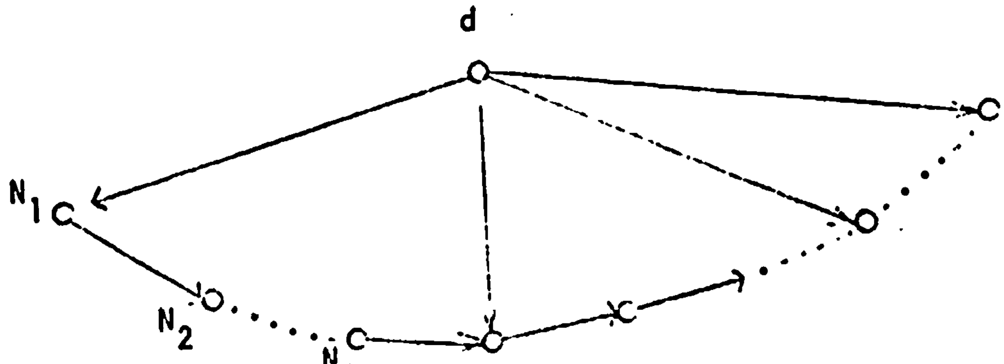


Fig. 10

More elaborate and more effective ways can be devised and will be considered in actual design of the memory structure for programming.

An example of a descriptor that does not need a ring is descriptor d = "Chapter". Given the node representing a chapter P - form is sufficient since it is very unlikely that anybody would want to trace all "second chapters" of the books in question.

Aspect 3.

In case that S_{IKN} is used for a new request, it might be desirable to create a new descriptor for certain nodes, i.e., nodes have to be represented in such a way that new descriptors can be attached. Be it in P or R form, the concept of double-ring has been formed in which all descriptors attached to N form their own rings of descriptors N. Let $d_1 \ldots d_n$ be all descriptors of N so that

$$d_1N \neq d_2N \neq d_3N \neq$$

Then $N(d_1, d_2, d_3)$ is a set of descriptors of N. The set is represented as a cycle of links attached to N called N-ring of N, where P or R-pointers are attached to $d_1, d_2 \ldots d$ as illustrated below.

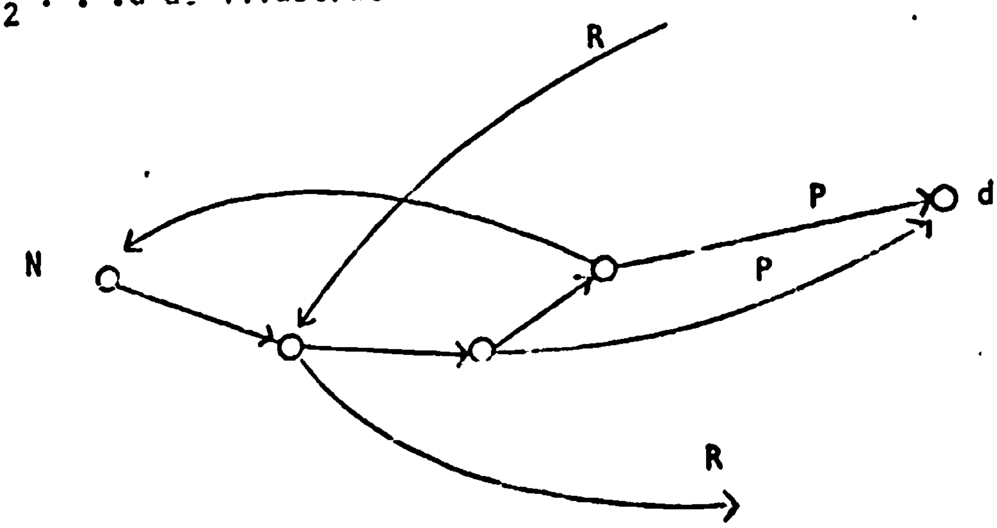


Fig. 11

Here P is P-form pointers and R is R-form pointers, and both are in the same N-ring.

Aspect 4.

Any descriptor must be represented in such a way that it can not only be retrieved, but also recognized. Whether it will be done by ring-matching in STITE or by some reference rules or "meta-descriptors" will be determined by the degree of sophistication of the system. In any case the double ring concept (that can be extended to n-ring concept) will provide a sufficiently adequate base for any later expansion of the system in this direction without any need for reprogramming or restructuring of the internal data-base. It is, however, important that the n-ring concept be accepted from the beginning, if not used immediately.

Aspect 5.

It will be advantageous for the processing in STITE for the descriptors to have their own associative structure that is determined by users or by recommendation.

Descriptors, forming a file of a system, can be structured independently of its current use, since the structuring process means addition of links or rings to D_L (which does not have existing links if accepted and incorporated from the beginning). Thus D_L can have its own thesaurus or glossary - like structure that will allow an amount of freedom in the selection of descriptors by the user. Descriptors that are not precisely known to the user can be located or discovered by the user in interactive-node.

Examples of descriptors for course outline:

State of the Art
Lecture
Course Outline
Quiz
Examination
Text
Theorem
Proof

Explanation

Application

History -- remarks

document

development

data

Term Paper

Assignment

Home Work

Problem -- solved

unsolved

solution

Formalization

Format

This tentative list indicates that there is a great deal of room for the internal structure of descriptors.

VI. CONCEPTS

In the context of STITE, the word, concept, is to be understood as a unit of knowledge that is defined by either definition or description and which structures the concept by relating it to other concepts.

Using D_c for definition or description, D_c is quadruple

$$D_c = (C_D, R_D, \{C_M\}_I, \{R_C\}) \qquad (C1)$$

where C_D is the defined concepts, C_u are a set of concepts chosen by the definition as primitive concepts of the definition, R_c is a set of relations chosen by D_c, and R_D is the relation of the description to C_D.

Concepts are basic units of knowledge stored in STITE for processing knowledge for the various purposes given by requests.

For use in STITE, it is desirable that concepts be structured in such a way that their definitions or descriptions can be accessed either as a whole (C1) or separately as each component of (C1). This offers the following advantages:

1. Processing of the requests is refined.
2. The system is enabled to associate components of the concept with supplementary information (bibliography, descriptors, other data relevant to the use of the concept in STITE).
3. It allows the concept to be linked into various files by itself or by its components.
4. The algorithms that process the concepts for various requests are simplified.
5. The effectiveness of the algorithms is increased.
6. Easy access to the concept is provided by the relations of its components.

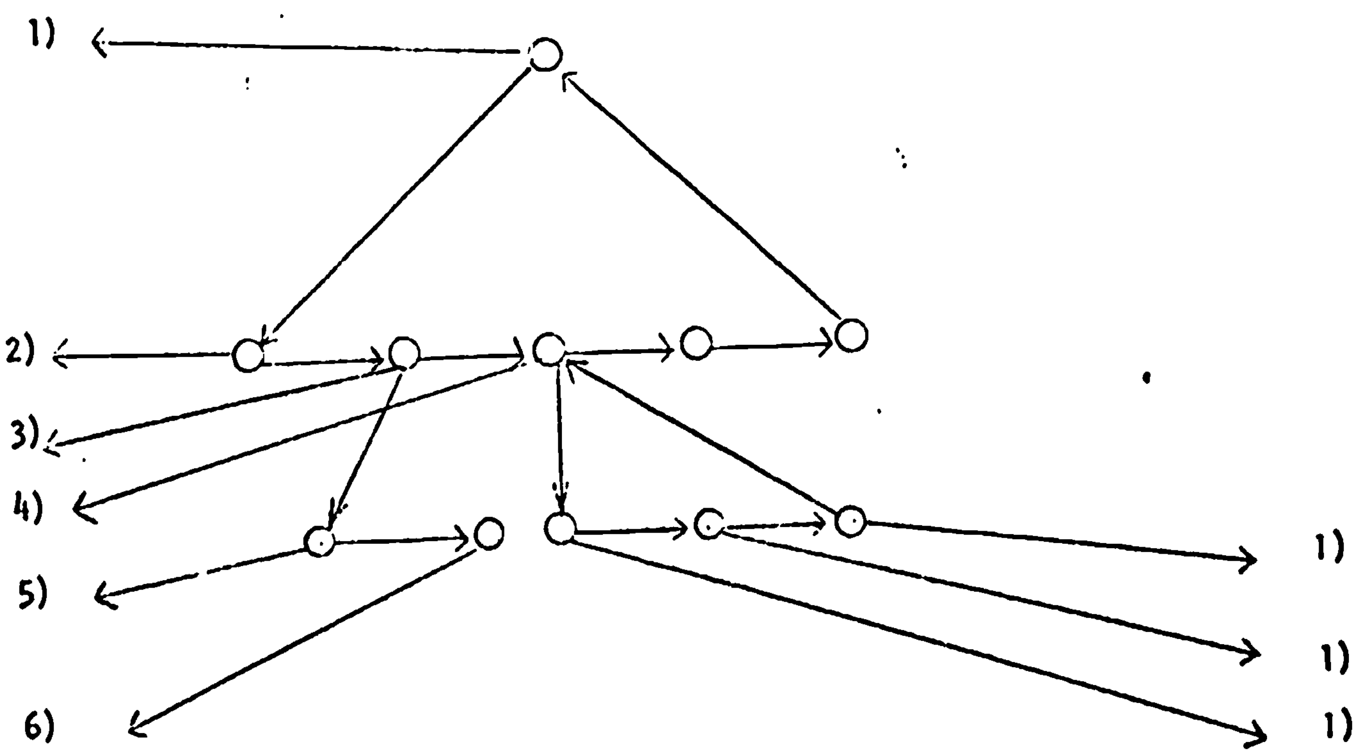
In many ways a concept can be represented as a structure. STITE proposes that it be done by using the so-called undesignated tree structure. "Undesignated" means that the nodes of the tree do not have a specific class or interpretation given in advance. Each node has its interpretation given by a link to the descriptors, in this case to the concept descriptors, where the descriptor represents the class of the node. In this way classes of the node are input data to the system so that much flexibility of the system is gained in terms of the independency of interpretation of internal structures of the system.

Having undesignated structures, algorithms for the structure processing need not depend on a particular interpretation of the class of the nodes. All data organization of the system is flexible and can be different for different areas of knowledge, different areas of the use, and different areas of users.

It is, then, the organization of the data that has to be properly prepared. If the processing of certain data becomes inconvenient, then it is data reorganization (eventually automated) that improves the situation rather than a rewriting the system for new algorithms.

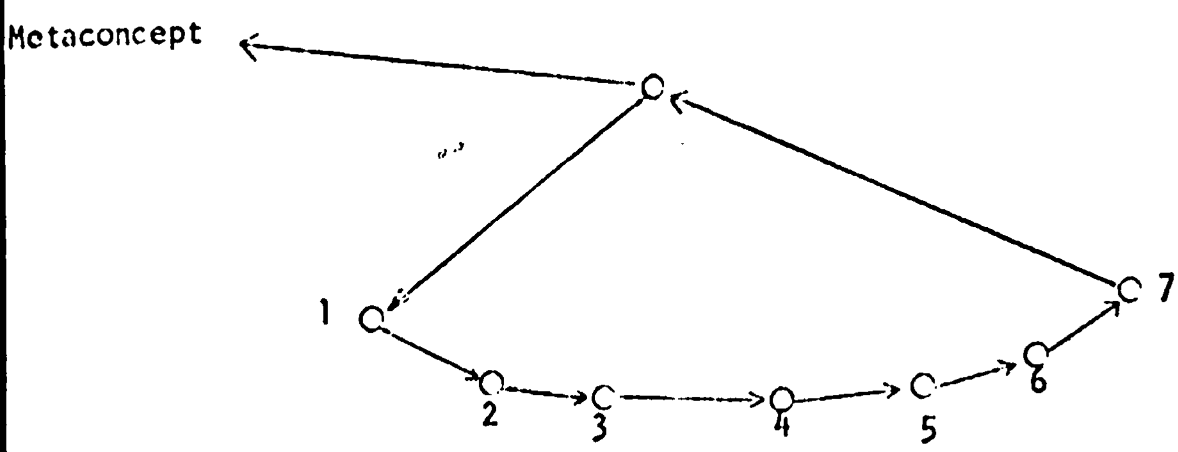
Fig. 12 is an example of the use of undesignated tree structure for the representation of a concept. Interpretation of a node is given by a link to the descriptor from the list of concept descriptors.

Fig. 13 shows the descriptors of the "concept". It illustrates the generality of the representation where meta-language and meta-structures are represented in the system by the same principle (method) as any other structure.



1) Concept C_D
2) Definition D_c
3) Description (C_m, R_c)
4) Concept name or symbol
5) Components
6) Relations
7) Primitive concepts (of the definition or description)

Fig. 12



1. Concept
2. Definition
3. Descriptor
4. Concept Name
5. Components of the Concept
6. Relations
7. Primitive Concepts

Fig. 13

VII. JUSTIFICATION OF THE REPRESENTATION

Any concept is a structure consisting of nodes and relations. It is necessary to know the nodes, their relations, to have them represented, and to have them described. All of this is provided for in the undesignated tree structure by the nodes of tree branches (lower level nodes) that can be expanded according to individual requirements by the nature of the represented concept.

The nodes can be indicated from various places of the data structure of STITE. Once indicated, it can be determined by what element is pointed to by its descriptor, by the lower level associations related to the component by following the tree down to a lower level, by the concept it belongs to by following the same level links or by the related concepts under the top-node concept by following the same level links.

There is, however. also a need to have the ability to point to the whole concept, i.e. to have access from the concept as such to its name or elements. It is the top node that provides for the representation of the concept in the lower resolution level (level with more suppressed details).

The tree structure method of representation automatically provides for a very important feature of the data structure. The processing algorithms can utilize "concept" in various resolution levels, from one-node representation of the concept to most detailed handling, without changing or restructuring the data base.

VIII. STATE OF THE ART (SOFTA)

1. Identification Of The AREA Of SOFTA

1.1 By keywords, short description of area in natural language

1.2 Detraction of: keywords, relations, structure of the area from the description

1.3 Extension of the area by:

lexical relation
associative structure
thesaurus information
science classification
by using other sources of
cohesions

2. Search For Information On SOFTA, Using AREA

2.1 Group internal resources of B

2.2 Group external resources (external nodes of B) for authors, headings, titles, bibliography abstracts

All of them being additional resources for extension of AREA, in which extension also links are made and preserved toward the literature sources (literature, authors, texts, unpublished materials, opinions of contacted professionals, etc.)

2.3 There is a feedback there: whenever AREA is updated the whole AREA is used for further search. Limits have to be established as to how far to go in which direction. When ARFA is established it must be formed on much wider ground but includes the neighbor area also comprising nodes of areas that are not to be ~ ed in or expanded in the final report. A process of finding, identifying, or establishing stopping points has to be at work at all times.

3. Compilation Of Extended AREA

3.1 Collected information in AREA is analyzed

3.1.1 Transformed into structure with classified nodes (node classification algorithms NCA)

3.1.2 Optional grouping of nodes (structures partitioning algorithms SPA for minimal interconnections)

3.1.3 Substructure untangling for the determination of the order of the paragraphs, sentences and other elements of the report (structure untangling algorithms SUNTA)

3.2 Transformation of the substructure

3.2.1 Into sentences, if detailed report with fluent text is desirable (structure to fluent text transformation algorithm SFTTA)

3.2.2 Into tables or names for enumerative type of text (structure to enumeration algorithm SENA)

3.2.3 Into pictures (structure to picture algorithm STOPA)

3.2.4 Into other forms serving as surface structure of the substructure

3.2.5 References of the source

4. Generation Of The Whole Report, Text, Article, Book

4.1 Content (content generating algorithm CGA)

4.2 Text (use of 3.2) including references

4.3 Bibliography (bibliography generating algorithms BGA for uniform and ordered bibliography

4.4 Other editing

PART THREE

LITERATURE SURVEY

LITERATURE SURVEY

Dorothy S. Hughes

I. INTRODUCTION

In order to achieve its purpose of designing a system to transfer scientific and technical information into a learning system, the STITE project will identify some existing learning tools and systems and the methods used in designing them and will delineate tools and systems already operative in various areas.

To date, the following sources have been searched:

Bibliography of Current Computer Literature - 1968 - 1970

Computer Abstracts - 1963 - date

Current Index to Journals in Education - 1970 - date

Educational Index - 1962 - date

Journal of Educational Data Processing - 1971 - 1972

Remaining among the major sources to be searched are Computing Reviews, Computer and Control Abstracts, Information Science Abstracts, Information Sciences, Science Abstracts, Series C, and Government Reports Announcements, as well as other bibliographies and indexes.

II. DEFINITION OF LEARNING TOOLS

The term, learning tools, could include any of the traditional aids to learning, such as text books, flash cards, or work books, but for the purposes of STITE, the definition will be limited to those instructional materials involving some kind of automation or computer activity. Included in this definition could be computer-assisted instruction, computer-managed instruction, automatic teaching, programmed instruction, television, filmstrips, tapes, teaching machines, and other media. Thornton and Brown (Ref. 106), in their book, New Media and College Teaching, list the varieties of tools and systems that are within the scope of the STITE project.

III. SYSTEMS APPROACH TO CURRICULUM DESIGN

A recurring theme in the literature of education is the importance of course design and curriculum planning, and with the application of technology to education has come the possibility of applying the systems approach to the area of curriculum design.

The systems approach first evolved as a method of solving problems in engineering and business and usually involves defining the elements of entry behavior of the target population, problem identification, task analysis, development, selection, and sequencing of media and materials, and an evaluation.

The elements, or steps, can be utilized in curriculum design, and this approach is significant for the STITE project in the development of the proposed descriptive model. At this stage in the literature search, the references that follow seem significant.

Stolurow (Ref. 99), writing of the psychological aspects of computer-assisted instruction, presents the teaching-learning process as one that does permit the development of an instructional system and describes his use of SOCRATES to conduct research relating to a model of tutorial instruction, to study basic variables relating to learning and the transfer of learning, and to develop a technology of using a computer based system to generate learning materials. He also describes some of the psychological principles, such as social reinforcement and paced conditions, that ought to be applied in the development of learning systems.

Cyrs (Ref. 25), maintains that the systems approach to curriculum design increases effectiveness by requiring precision in the definition of educational objectives and then by redesigning the entire educational process in order to ensure achievement of the specific goals. He develops a flow chart to illustrate the process.

To describe instructional design as a series of steps is a common method of explaining the process, although not all writers agree on the number or type of steps necessary. Knirk (Ref. 57), names six components, those of goal determination, analysis, prescription, implementation, evaluation, and revision. Tuckman (Ref. 109), says that the process proceeds in a systematic way, is relevant to its parts, and deals with measurable behavior. Hunter (Ref. 52), lists seven steps in the process of preparing programs for military technical training. Parry (Ref. 79), in addition to giving the details of the procedure by which programmed instruction is prepared and illustrating the process with a flow chart, suggests external and internal features on which a particular program can be evaluated. Felhusen and Treffinger (Ref. 34), define steps in design as the analysis of concepts and principles to be taught, formulation of objectives, and choice of methods to be used in achieving the objectives.

Hansen (Ref. 50), describes a systems approach model for CAI curriculum development at Florida State University and documents his experience with instructional strategies there. Decker (Ref. 28), explains his learning model with the components of a class assembly, a learning laboratory equipped with printed materials, audio-tapes, filmstrips and other media, and thirdly, feedback sessions using self-tests and quizzes.

Boblick (Ref. 8), outlines a three-step process that a classroom teacher may use to develop instructional segments for classroom use.

Bunderson (Ref. 12), describes an instructional design model and a learning task which was designed and developed in accordance with the model.

Oliver (Ref. 77), pleas for more organization in the goals, methods, and instrumental procedures with which the designer must deal, while Banathy (Ref. 4), explores the relationships between sources of information, curriculum design, and student achievement and uses several diagrams to illustrate this interaction.

While Williams (Ref. 117), writes of engineering education, his chart of the learning operation, showing various channels of communication that affect that operation, is valid for any subject area.

Most writers emphasize the importance of defining educational goals in curriculum design and Brown (Ref. 11), suggests that most educators tend to confuse the goals of a course with its content. He, as well as VanderMeer (Ref. 112), speculates that new media and methods may make it possible to achieve a wider range of goals in the curriculum.

Ammerman (Ref. 2), identifies some of the problems in developing learning objectives and concludes that successful objectives must be based on factors that influence their meaningfulness and their usefulness. Mager (Ref. 69), stresses the importance of defining what is to be taught and what measurable behavior is to be expected at the end of the course. His book is written as a program itself with instructions for working through it.

Montague (Ref. 74), emphasizes the necessity for being specific about behavioral objectives and says that passive words such as "know" and "understand" should be replaced by words like "construct", "identify", and "describe".

Rosave (Ref. 39), maintains that educational objectives should be defined in terms of the requirements for life in the world rather than life in the isolated classroom. Eiss (Ref. 32), requests more attention to goals and strategies in planning science curricula, and Robinson (Ref. 86), writing of science education, appeals for new approaches.

Writing of engineering education, Waina (Ref. 116), demonstrates a method of specifying educational objectives by specifying what an engineer is expected to know how to do, and this method is valid for other fields as well.

A systems approach to curriculum design must allow for individual differences in students, and Burke (Ref. 13), emphasizes the importance of a system that allows each student to follow his own direction and fulfill his own goals. Stolurow (Ref. 100), maintains that a successful instructional program must handle three variables, i.e. who is being taught, what is critical, and how the teaching is to be done. Cohen's (Ref. 21), list of priorities for curriculum design includes differentiated student curricula, media, grouped or individual curricula, and teacher roles. He (Ref. 21), also stresses emotional, as well as cognitive, needs of the student.

Mizenko (Ref. 73), describes a tutorial model that provides for the accommodation of high, middle, and low aptitude students.

Smith (Ref. 95), considers factors that bear on training effectiveness.

Motivation is an area that requires more careful investigation, and a systems approach model should incorporate both effective, as well as cognitive, learner variables in design, according to McCombs (Ref. 67). Filip (Ref. 35), emphasizes the humanistic dimension in planning instruction while Woodson (Ref. 118), concludes that the most important outcome of computer assisted instruction may be what it teaches educators about the instructional process.

A model for revising materials designed systematically for education, as it is described by Rayner (Ref. 85), is significant for the STITE project for revision or updating can be an important feature of the proposed model.

IV. PROGRAMMED INSTRUCTION

Forerunner of present-day, highly sophisticated instructional systems were the earlier and technically simpler teaching machines. While many of these machines, because of their simple and non-automated configuration, would not fit into the STITE definition of learning tools, they are nevertheless of significance for STITE because of their historical role in the development of computer-assisted instruction and because of programmed instruction techniques that were developed for use with them.

Margulies (Ref. 71), defines programmed instruction and gives some utilization data, such as costs and availability. Calvin (Ref. 20) describes some of the hopeful aspects of programmed instruction. Fry (Ref. 36), presents the historical development of teaching machines, along with some discussion of practical problems, while Garner (Ref. 38) describes the chronological development of programmed instruction.

A state-of-the-art report on automatic teaching is given by Galanter (Ref. 37).

A comprehensive reference source on teaching machines and the techniques of instruction associated with them is provided by Lumsdaine (Ref. 64), who also surveys current activities and trends (1960).

More recently Dunn and Holroyd (Ref. 30), edit a volume on the proceedings of a conference on programmed learning and educational technology that gives a comprehensive review of the present state of educational technology (1968).

Cram (Ref. 23), explains teaching machines by arranging his text in a "scrambled book" form.

A good discussion of the psychology of learning and its relation to teaching machines and program preparation is given by Austivick (Ref. 3). Deterline (Ref. 29), and Lumsdaine (Ref. 63), also take into account learner behavior and its relationship to the teaching effectiveness of programmed instruction.

The technique of writing good programs for programmed instruction is described in detail by Lysaught (Ref. 66). Thomas (Ref. 105), after delineating the steps in program writing, then illustrates those steps in programs on elementary electricity and Pythagoras' Theorem. Kay (Ref. 55), also describes program writing techniques.

The personal characteristics of a successful program writer are described by Smith (Ref. 94), as well as the characteristics of a successful program.

Callender (Ref. 19), writes a handbook-type manual as an introduction and reference text for those instructors using programmed learning or organizing courses for programmed learning.

Gilbert (Ref. 42), relates programmed learning to university instructional services by classifying the instructional needs of students, faculty, administration, and research staff.

Unwin (Ref. 111), and Tobin (Ref. 107) both present reports on, and papers from, conferences on programmed learning while MacDonald (Ref. 68), lists commercial firms engaged in the development of teaching machines and programmed learning materials.

V. COMPUTER-ASSISTED INSTRUCTION

With the introduction of computers into the area of instruction in the late fifties and their increased popularity and usage in the sixties, there has also arisen a considerable body of literature and information concerning the definition, scope, possibilities, and problems of computer assisted instruction. While it is not necessary for the STITE project to investigate all of these writings, it is desirable to examine some of the more significant ones in order to determine the context within which the STITE system might possibly function. Thus far the literature search reveals the items that follow that seem to be particularly relevant.

Zinn (Ref. 121), gives a good overview of the development and direction of instructional uses of computers, as do Silvern (Ref. 93), and Stolurow (Ref. 98). Zinn (Ref. 121), defines and describes their purposes and modes of use in education. Suppes (Ref. 102), writes of the advantages of types of pupil computer interaction CAI affords (i.e. drill & practice, tutorial, actual dialogue) and also (Ref. 101), describes some current activities and some projects of the future.

Gerald (Ref. 40), reports on an early work shop conference that focused on learning and technical aspects of computers and education, and Bushnell (Ref. 16 and Ref. 14), describes present and future roles of digital computers in American education. Goodlad (Ref. 44), discusses present and potential applications of computers in education, and Margolin (Ref. 70), gives an interdisciplinary view of computers in the classroom.

Some conjectures about computers in education in the future are made by Crowell (Ref. 24), and by Zinn (Ref. 120), and Caffrey (Ref. 17), in a non-technical report, makes a general survey of the possibilities of their use in higher education.

Computer-assisted instruction at the U.S. Naval Academy is described by Concord (Ref. 22), and by Sandeford (Ref. 90).

A survey of the present state of educational technology over the world is given in a special issue of the magazine, Educational Technology, November, 1969 (Ref. 31). It includes articles on seventeen countries.

Computer-assisted instruction came into existence at a time when traditional education practices were being severely critized and consequently may have been seized upon over-eagerly as the answer to many of education's ills, according to Gentile (Ref. 39). While earlier writers were enthusiastic in their praise of, and their expectations for, CAI, some more recent writers take a less exalted view of computers in education.

Grayson (Ref. 46), in writing about problems in computer-assisted instruction, suggests that ignorance about the learning process, rather than technical capabilities, may be the limiting factor in computer-assisted instruction, and Rogers (Ref. 88), also discussing problems of computers in education, lists gaps that are left in the instructional process, limitations imposed by systems, and difficulties in the production of materials as areas requiring attention. Darnowski (Ref. 27), includes technological problems, such as break-downs and lack of flexibility, as well as educational problems in his survey of efforts and potentials of CAI. Oettinger (Ref. 76), says that some of the earlier claims of educational technology now seem unfounded, while Abramson (Ref. 1), sees its greatest potential in very large-scale implementation.

Gentile (Ref. 39), in his critique of computer-assisted instruction, emphasizes the necessity for research in teaching-learning variables, in individual differences, and in learning effectiveness. Bushnell (Ref. 15), suggests that computers can be used effectively in instruction as problem-solving tools and in experimentation and simulation, but he finds them inefficient in tutorial and drill-and-practice use. Kanner (Ref. 54), claims that CAI's acceptance by the educational community must be based on clear-cut advantages that it offers over other methods of teaching.

Computer-managed instruction (CMI), is a process related to computer-assisted instruction in which the computer is used to help the teacher administer and guide the instruction process. It is described by Vierling (Ref. 115), and Silberman (Ref. 92), and an application is described by Hagerty (Ref. 49).

VI. SCIENCE AND TECHNICAL LEARNING SYSTEMS IN OPERATION

Identification and description of learning systems presently operative can be helpful to the development of the STITE system by revealing some of the possibilities and difficulties that exist in the actual design and operation of learning systems. There are many such courses now functioning successfully in various fields, and descriptions of some of them follow. Other fields, as well as additional writings about the ones included here, will be added as the literature search progresses.

In the field of science, Purnell (Ref. 84), describes a system approach to science education, and Lunetta (Ref. 65), describes some specific applications. Lambe (Ref. 60) compares the advantages and disadvantages of simulated laboratory experiments as opposed to actual ones. Vierling (Ref. 114), describes computer applications in physics, chemistry, and engineering at the U.S. Naval Academy.

Tan (Ref. 104), discusses the potential of small computers in the simulation of genetic phenomena that, because of time limitations, cannot be illustrated in an ordinary laboratory course, and Owen (Ref. 78), describes laboratory computations and preparation of some formulas and graphs that can be facilitated with computations by computer. Gerrick (Ref. 41), describes the use of time-share computers in biology teaching, and Grimes (Ref. 47), writes of the use of a computer to identify bacteriological unknowns.

Gill and others (Ref. 43), describe the use of computers in the demonstration of ecological systems, whereby, with models and simulations, ecological relationships and processes can be shown.

The field of mathematics has made extensive use of systems in teaching, and Zoet (Ref. 122), and Travers (Ref. 108), both discuss the use of computers in mathematics education.

Mathews (Ref. 72), describes the way in which computing facilities are used as a supplementary laboratory course with conventional mathematics courses at Iowa State University. A computer-oriented calculus course based on CRICISAM at the U.S. Naval Academy is described by Benac (Ref. 5), and Leinback (Ref. 61), shows how a small college (Gettysburg) with limited facilities and a small mathematics department can make effective use of computer-assisted instruction.

Montague (Ref. 75), shows how matrix algebra can be effectively introduced with computer programming, and at the University of North Dakota the ordinary differential equation course has been replaced by a computer-supplemented one, according to Kemper (Ref. 56). The cone problem is discussed by Damaskos (Ref. 26).

In the field of statistics, Grubb and Selfridge (Ref. 48), describe the machine used in an experimental course in statistics and compare three modes of instruction (computer, lecturer, and programmed text) by comparing time spent in the course and the grade received.

Computers in the physics curriculum are discussed by Blum (Ref. 7), and both Blum (Ref. 6), and Shirer (Ref. 91), describe a computer-based physics course. A multi-media general physics course at Florida State University, explained by Kromhaut and others (Ref. 58), makes use of audiotaped lectures, movies, and film strips, as well as textbook reading assignments, quizzes, and homework problems. Boblick (Ref. 10), describes the use of simulations in the teaching of a general physics course, while Vierling (Ref. 113), shows how computer-generated drill and text procedures are applied in physics teaching.

Chemical education has made widespread application of computers, and among the program descriptions would be Grandey (Ref. 45), who describes the use of the PLATO system, using a TV screen and keyset for each student to determine chemical formulas and equations at the University of Illinois. Lagowski (Ref. 59), discusses the various types of computer-assisted instruction possible in chemistry education including simulated experiments, drill and practice, and tutorial activities, and he includes a list of programs in chemistry developed at the University of Texas. A Perdue University program providing for the use of the computer in data acquisition and data processing is designed as a laboratory course that accompanies the traditional type course, and it is discussed by Perone and Eagleston (Ref. 80). Stevenson (Ref. 97), points out the advantage of using programmed computations for problems in such areas as ionic equilibrium, quantum mechanics, and statistical mechanics, because doing such computations "by hand" would require so much time that classroom demonstrations would be prohibitive.

Basic chemical formula writing taught by computer is described by Boblick (Ref. 9). Smith (Ref. 96), explains the use of the PLATO system in undergraduate courses in organic chemistry at the University of Illinois, and Rodewald (Ref. 87), discusses another organic chemistry course that uses colored filmstrip frames, under direct computer control, as an integral part of the course.

Perone (Ref. 80), gives a detailed description of computer application in teaching gas chromatography by describing the programming and instrumentation necessary and by listing lab assignments and required materials and equipment.

Lower (Ref. 62), explains the use of audiotapes prepared by the lecturer as a means of clarifying problem areas in an introductory chemistry course.

Teaching numerical methods in chemistry by teaching computer programming and by surveying topics in numerical analysis are viewed by Johnson (Ref. 53), as ways of updating the education of graduate and undergraduate students in chemistry.

Young (Ref. 119), lists three criteria to be used in determining whether or not computers should be used in chemical education.

VII. REFERENCES

1. Abramson, T., and Max Weiner. "Some Detours and Alternate Routes Leading to Large-Scale Exemplary Uses of CAI." Educational Technology, 12: 14-16 (July, 1972).

2. Ammerman, Harry L., and William H. Melching. The Derivation, Analysis, And Classification of Instructional Objectives. Technical Report 66-4. Alexandria, Virginia, Human Resources Research Organization, 1966. 58pp.

3. Austwick, K. Teaching Machines and Programming. New York, Macmillan Company, 1964. 205pp.

4. Banathy, B.H. "Information Systems for Curriculum Planning." Educational Technology, 10:25-28 (November, 1970).

5. Benac, T. "The Computer and the Calculus." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:13-21 (1971).

6. Blum, R. "A Computer Based Introductory Physics Course." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:51-57 (1971).

7. Blum, R. "Computers in the Physics Curriculum." Physics Teacher, 7:339-340 (September, 1969).

8. Boblick, J.M. "Applying the Systems Approach to Curriculum Development In The Science Classroom." Science Education, 55:103-113 (April, 1971).

9. Boblick, J.M. "Use of Computer-Assisted Instruction to Teach Basic Chemical Formula Writing Skills." School Science and Mathematics, 71:781-789 (December, 1971).

10. Boblick, J.M. "Use of Computer Simulation in the Teaching of High School Physics." Science Education, 54:77-81 (January 1971).

11. Brown, R.M. "Instructional Systems Development: Cost and Content in College Courses." Educational Technology, 11:26-27 (May, 1971).

12. Bunderson, C.V., W.P. Oliver, and P.F. Merrill. The Design of An Abstract Hierarchical Learning Task For Computer-Based Instructional Research. Austin, Texas University, 1971. 20pp. AD745717

13. Burke, J.B., Julia O'Neill, and Kay Welsh. "A Humanized Model of a Computer Managed Instructional System." Educational Technology, 12:31-36 (November, 1972).

14. Bushnell, D.D., and D. W. Allen, eds. The Computer in American Education. New York, John Wiley, 1967. 300 pp.

15. Bushnell, D.D. "Computers in Education." Computers and Automation, 12:8-10 (March, 1963).

16. Bushnell, D.D., Introducing the Docile Technology: In Memoriam of CAI. Washington, D.C., Academy for Educational Development, Inc., 1970. 35pp. ED 039703

17. Caffrey, John, and Charles J. Mosmann. Computers On Campus; A Report To The President on Their Use and Management. Washington, D.C., American Council on Education, 1967. 207pp.

18. Calfee, R.C. "Information-Processing Models and Curriculum Design." Educational Technology, 10:30-38 (April, 1970).

19. Callender, P. Programmed Learning: Its Development and Structure. London, Longmans, 1969. 120pp.

20. Calvin, A. Programmed Instruction: Bold New Venture. Bloomington, Indiana University Press, 1969. 250pp.

21. Cohen, Ronald D. "Instructional Priorities For Development of Science Curricula." Science Education, 56:477-485 (October, 1972).

22. Concord, Albert E. "Educational Applications of Time-Sharing At The United States Naval Academy." Association for Educational Data Systems Journal, 3:37-49 (December, 1969).

23. Cram, David. Exploring "Teaching Machines" and Programming. San Francisco, Fearon Publishers, 1961. 86pp.

24. Crowell, F.A., and S.C. Traegde. "The Role of Computer In Instructional Systems: Past and Future" Proceedings of the 22nd Association For Computing Machinery National Conference, 67:417-425 (1967).

25. Cyrs, Thomas El, Jr., and Rita Lowenthal. "A Model For Curriculum Design Using a Systems Approach." Audiovisual Instructor, 15:16-18 (January, 1970).

26. Damaskos, N.J. "Case Study in Mathematics: The Cone Problem." Mathematics Teacher, 62:642-649 (December, 1969).

27. Darnowski, V.S. "Computer-Aided Instruction." Science Teacher, 35:22-26+ (January, 1963).

28. Decker, Edward H. "The Systems Approach; A New Educational Technique." Science Teacher, 35:26-27 (November, 1968).

29. Deterline, W.A. An Introduction to Programmed Instruction. Englewood Cliffs, New Jersey, Prentice-Hall, 1962. 131pp.

30. Dunn, W.R., and C. Holroyd, eds. Aspects of Educational Technology: Proceedings of the Conference on Programmed Learning and Educational Technology. Glasgow, Scotland, University of Glasgow, 1968. 671pp.

31. Educational Technology, 9 (November, 1969).

32. Eiss, A.F. "A Systems Approach to Developing Scientific Literacy." Educational Technology, 10:36-40 (January, 1970).

33. Eiss, A.F., and G.D. Ofiesh, eds. "Science Education and Educational Technology." Educational Technology, 10:9-69 (January, 1970)

34. Feldhusen, J.F., and D. J. Treffinger. "Psychological Background and Rationale for Instructional Design." Educational Technology, 2:21-24 (October, 1971).

35. Filip, R.T. "Systematic Approach to Instruction: Innovative and Sensitive." Audio-Visual Media, 4:6-11 (Spring, 1970).

36. Fry, Edward B. Teaching Machines and Programmed Instruction. New York, McGraw-Hill, 1967. 244pp.

37. Galanter, E., ed. Automatic Teaching: The State of the Art. New York, John Wiley & Sons, 1959. 198pp.

38. Garner, W. Lee. Programmed Instruction. New York, The Center for Applied Research in Education, Inc., 1966. 118pp.

39. Gentile, J.R. "First Generation of Computer-Assisted Instructional Systems: An Evaluative Review." AV Communication Review, 15:23-53 (Spring, 1967).

40. Gerard, R.W., and J.G. Miller, eds., Computers and Education: A Workshop Conference at University of California, Irvine. New York, McGraw-Hill, 1967. 307pp.

41. Gerrick, D.J. "Time-Share Computers in Biology." American Biology Teacher, 33:526-527 (December, 1971).

42. Gilbert, J.E. "Programmed Learning and University Instructional Services." In Calvin, A., Programmed Instruction: Bold, New Venture. Bloomington, Indiana University Press, 1969. p.213-240.

43. Gill, R.W., Stephen Bryant, and Terry Mellon "Uses of Computers in the Teaching of Ecology." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:171-175 (1971).

44. Goodlad, J.I., J.F. O'Toole, Jr., and Louise Tyler Tyler. Computers and Information Systems in Education. New York, Harcourt, Brace and World, 1966. 152pp.

45. Grandey, R.C. "Use of Computers to Aid Instruction in Beginning Chemistry." Journal of Chemical Education, 48:791-794 (December, 1971).

46. Grayson, L.P. "Computer-Assisted Instruction for University Education." In ASEE Symposium on the Application of Technology to Education. Washington, American Society of Engineering Education, 1969. p. 7-12.

47. Grimes, G.M., et al. "Identification of Bacteriological Unknowns: A Computer-Based Teaching Program." Journal of Medical Education, 47:289-292 (April, 1972).

48. Grubb, R.E., and Lenore Selfridge, "Computer Tutoring in Statistics." Computers and Automation, 13:20-26 (March, 1964).

49. Hagerty, N.K. Development and Implementation of a Computer-Managed Instruction System in Graduate Training. Tallahassee, Florida, Florida State University, 1970. 175pp. AD709437.

50. Hansen, D.N. Development Processes in CAI Problems, Techniques and Implications. Tallahassee, Florida State University, 1969. 31pp. AD 696533.

51. Holtzman, W.H., ed. Computer-Assisted Instruction, Testing, and Guidance. New York, Harper and Row, 1970. 402pp.

52. Hunter, H.G. "Process for Developing Course Content for Military Technical Training." Educational Technology, 10:S10-18 (June, 1970).

53. Johnson, K.J. "Numerical Methods in Chemistry: A Computer Applications Course." Journal of Chemical Education, 47:819-820 (December, 1970).

54. Kanner, J.H. "CAI - The New Demonology?" Datamation, 14:38-40 (September, 1968).

55. Kay, Harry, Bernard Dodd, and Max Sime. Teaching Machines and Programmed Instruction. Harmondsworth, Middlesex, England, Penguin Books, 1968. 173pp.

56. Kemper, G.A. "Computer (Programmable Calculator) Supplemented Ordinary Differential Equations." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:27-40 (1971).

57. Knirk, F.G., and C.G. Gentry. "Applied Instructional Systems." Educational Technology, 11:58-62 (June, 1971).

58. Kromhout, Ora M., Steve Edwards, and Guenter Schwartz. "A Computer-Guided General-Education Physics Course." American Journal of Physics, 37:995-1007 (October, 1969).

59. Lagowski, J. J. "Computer-Assisted Instruction in Chemistry." In Holtzman, W.H., Computer-Assisted Instruction, Testing, and Guidance. New York, Harper and Row, 1970. p. 283-298.

60. Lambe, E.D. "Simulated Laboratory in the Natural Sciences." In Holtzman, W.H., ed., Computer-Assisted Instruction, Testing and Guidance. New York, Harper and Row, 1970. p. 299-306.

61. Leinbach, L.C., "Calculus As A Laboratory Course." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:13-17 (1971).

62. Lower, S.K., "Audio-Tutorial and CAI Aids: For Problem Solving In Introductory Chemistry." Journal of Chemical Education, 47:143-146 (February, 1970).

63. Lumsdaine, A.A., ed. Student Response In Programmed Instruction; A Symposium on Experimental Studies of Cue and Response Factors In Group And Individual Learning From Instructional Media. Washington, D.C., National Academy of Sciences-National Research Council, 1961. 555pp.

64. Lumsdaine, A.A., and Robert Glaser, Teaching Machines and Programmed Learning: A Source Book. Washington, D.C., Department of Audio-Visual Instruction, National Education Association, 1960. 724pp.

65. Lunetta, V.N., and O.E. Dyrli, "Computers in the Science Curriculum: Some Concrete Applications in the Physical Sciences." Science Education, 54:147-154 (April, 1970).

66. Lysaught, Jerome P., and Clarence M. Williams. A Guide to Programmed Instruction. New York, John Wiley, 1963. 180pp.

67. McCombs, Barbara L., A. John Eschenbrenner, Jr., and Harold F. O'Neil, Jr. "An Adaptive Model for Utilizing Learner Characteristics in Computer Based Instructional Systems." Educational Technology, 13:47-51 (April, 1973).

68. MacDonald, Neil "Teaching Machines and Programmed Learning: Roster of Organizations and What They are Doing." Computers and Automation, 13:30-32 (March, 1964).

69. Mager, R.F. Preparing Instructional Objectives. Palo Alto, California, Fearon Publishers, 1962. 60pp.

70. Margolin, J.B., eds. Computers In the Classroom: An Inter-Disciplinary View of Trends and Alternatives. New York, Spartan Books, 1970. 382pp.

71. Margulies, Stuart, and Lewis D. Eigen. Applied Programed Instruction. New York, John Wiley, 1962. 387pp.

72. Mathews, J.C. "Calculus and the Computer: A Parallel Approach." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:23-26 (1971).

73. Mizenko, A.J., and A.A. Evans, An Instructional Model for Computer Assisted Instruction. Fort Monmouth, New Jersey, Army Signal Center and School, 1971. 25pp. AD 745409.

74. Montague, E.J., and David P. Butts. "Behavioral Objectives." Science Teacher, 35:33-35 (March, 1968).

75. Montague, M.A. "Introducing Matrix Algebra with Computer Programming." Mathematics Teacher, 61-65-72 (January, 1971).

76. Oettinger, A., and S. Marks. "Educational Technology: New Myths and Old Technology; Watertown (Mass.) Language Laboratory and Stanford-Brentwood CAI Laboratory." Harvard Educational Review, 38:697-755 (Fall, 1968).

77. Oliver, G.L. "Toward Improved Rigor in the Design of Curricula." Educational Technology, 10:18-23 (April, 1970).

78. Owen, H.M. "The Computer in Undergraduate Genetics." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:176-180 (1971).

79. Parry, S.B. "Programmed Instruction: The Systems Approach to Training." Systems and Procedure Journal, 16:26-31 (January-February, 1965).

80. Perone, S.P., and J.F. Eagleston. "Introduction of Digital Computers Into the Undergraduate Laboratory." Journal of Chemical Education, 48:317-322 (May, 1971).

81. Perone, S.P., and J.F. Eagleston. "On-Line Digital Computer Applications in Gas Chromatography in Undergraduate Analytical Experiments." Journal of Chemical Education, 48:438-442 (July, 1971).

82. Pipe, Peter. Practical Programming. New York, Holt, Rinehart, and Winston, Inc., 1966. 70pp.

83. Postlethwait, S.N. The Audio-Tutorial Approach to Learning, Through Independent Study and Integrated Experiences. Minneapolis, Burgess Publishing Company, 1969. 149pp.

84. Purnell, C.H. "Del Mod System: A Systems Approach to Science Education." Science Teacher, 39:37-39 (September, 1972).

85. Rayner, G.T. An Empirical Study of A Methodology for the Revision of Systematically Designed Educational Materials. Technical Report No. 24. Tallahassee, Florida State University, Computer-Assisted Instruction Center, 1972. 163pp. ED 067877

86. Robinson, J.T. "Philosophical and Historical Bases of Sciences Teaching." Review of Educational Research, 39:459-471 (October, 1969).

87. Rodewald, L.B., et al. "Use of Computers in Organic Chemistry Instruction." Journal of Chemical Education, 47:134-136 (February, 1970).

88. Rogers, J.L. "Current Problems in CAI." Datamation, 14:28-33 (September, 1968).

89. Rosave, P.E. "A Conjecture About the Teacher's Future Role." Educational Technology, 10:13-20 (February, 1970).

90. Sandeford, W.H., et al. Naval Academy's CAI Project (Computer Assisted Instruction Project). Annapolis, Maryland, Naval Academy, 1972. 107pp. AD 746355.

91. Shirer, D.L. "Using A Computer Instead of Calculus In An Introductory Physics Course." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:58-63 (1971).

92. Silberman, H.F. "Computer-Managed Instruction: Use of a Computer to Monitor Student Performance." In ASEE Symposium On The Application Of Technology To Education. Washington, D.C., American Society for Engineering Education 1969. p. 14-16.

93. Silvern, G.M., and L.C. Silvern. "Programmed Instruction And Computer Assisted Instruction - An Overview." Proceedings of the Institute of Electrical and Electronics Engineers, 54:1648-1655 (1966).

94. Smith, D. E. P. "Speculations: Characteristics of Successful Programs and Programmers." In Galanter, E., ed. Automatic Teaching: The State of the Art. New York, John Wiley, 1959. p. 91-102.

95. Smith, Robert G. The Design of Instructional Systems. Technical Report 66-18. Alexandria, Virginia, Human Resources Research Office, 1966. 92pp.

96. Smith, S.G. "Use of Computers in the Teaching of Organic Chemistry: PLATO System." Journal of Chemical Education, 47:608-611. (September, 1970).

97. Stevenson, P. "Direct Classroom Use of a Time-Sharing Computer in Chemical Education." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:112-116 (1971).

98. Stolurow, L. M. Computer-Assisted Instruction. Detroit, Michigan, American Data Processing, Inc., 1968. 94 pp.

99. Stolurow, L.M. "Computer-Based Instruction: Psychological Aspects and Systems Conception of Instruction." Journal of Educational Data Processing, 4:193-215 (Fall, 1967).

100. Stolurow, L.M. Some Factors In The Design of Systems for Computer-Assisted Instruction. Cambridge, Mass., Harvard University, 1968. 45pp. AD 678740

101. Suppes, P., and Max Jerman. "Computer Assisted Instruction." National Association of Secondary School Principals Bulletin, 54:27-40 (February, 1970).

102. Suppes, P. "The Uses of Computers in Education." Scientific American, 215:206-220 (September, 1966).

103. Taber, J.I., Robert Glaser, and Halmuth Schaefer. Learning and Programmed Instruction. Reading, Massachusetts, Addison-Wesley, 1965. 182pp.

104. Tan, J.C., "Applications of a Wang Calculating/Computing System in the Undergraduate Genetics and Biometry Laboratory Instructions." Proceedings of the Second Annual Conference on Computers in the Undergraduate Curriculum, 2:181-186 (1971).

105. Thomas, C.A., et al. Programmed Learning In Perspective: A Guide to Program Writing. Chicago, EMI Educational Methods, Inc., 1963. 183pp.

106. Thornton, J.W., and James W. Brown, eds. New Media and College Teaching. Washington, D.C. Department of Audiovisual Instruction, National Education Association, 1968. 194pp.

107. Tobin, J.J., ed. Problems and Methods In Programmed Learning; The Proceedings of The 1967 APL/NCPL Birmingham Conference. Birmingham, England, National Centre For Programmed Learning, School of Education, University of Birmingham, 1967. Five Parts.

108. Travers, K. J. "Mathematics Education and the Computer Revolution." School Science and Mathematics, 71:24-34 (January, 1971).

109. Tuckman, B.W., and K. J. Edwards. "Systems Model for Instructional Design and Management." Educational Technology, 11:21-26 (September, 1971).

110. Twelker, P.A. "Designing Simulation Systems." Educational Technology, 9:64-70 (October, 1969).

111. Unwin, Derick, and John Leedham, eds. Aspects of Educational Technology: The Proceedings of the Programmed Learning Conference Held at Loughborough 15-18 April 1966. London, Metheun, 1967. 545pp.

112. VanderMeer, A. "Impact of New Materials and Media on Curriculum Design." Educational Technology, 10-53-57 (April, 1970).

113. Vierling, A.F. "Computer-Generated Drill and Test." American Journal of Physics, 40:631-632 (April, 1972).

114. Vierling, A.F., J.S. Vierling, and J.F. Kropf, Computer-Assisted Learning. New York, Hafner Publishing Company, 1969. 369pp.

115. Vierling, J.S. and M. Shivaram. "On-Line Computer Managed Instruction - The First Step." Proceedings of the 1970 Fall Joint Computer Conference, 37:231-239 (1970).

116. Waina, R.B. "Systems Design of Curriculum." Engineering Education, 60:97-100 (October, 1969).

117. Williams, E.M. "Towards A Systems Approach in the Design of Learning Systems." In ASEE Symposium on the Application of Engineering Education, 1969. p. 19-22.

118. Woodson, Charles, E. "Programming Heuristics For The Instructional Process." Educational Technology, 13:48-51 (March, 1973).

119. Young, J.A. "Computers in Chemical Education: Yes, No, or Yes, If?" Journal of Chemical Education, 47:758-759 (November, 1970).

120. Zinn, K.L. "Computers In The Instructional Process: Directions For Reasearch And Development." Communications of the Association for Computing Machinery, 15:648-651 (July, 1972).

121. Zinn, K.L. "Instructional Uses of Interactive Computer Systems." Datamation, 14:22-27 (September, 1968).

122. Zoet, C.J. "Computers in Mathematics Education." Mathematics Teacher, 62:563-566 (November, 1969).

APPENDIX

A. Institutions & Persons Contacted

Dr. James Christinsen
Department of Chemical Engineering
University of Oklahoma
Norman, Oklahoma 73069

Mrs. Selma Dublin
Academy for Instructional Technology
Academy for Educational Development
1424 16th Street NW
Washington, D.C. 20036

EDUCOM
Box 364
Rosedale Road
Princeton, New Jersey 08540

Mr. Victor Fuchs
Media Specialist
Southern States Cooperative Learning Resources System
Auburn University in Montgomery
Montgomery, Alabama

Dr. Alvis Hardie
Agency for International Development
Washington, D.C.

Mr. Stephen Moseley
Academy for Educational Development
1424 16th Street NW
Washington, D.C. 20036

Mrs. Jane Wolper
Information Pool
American Institute of Physics, Inc.
Education Division
P. O. Box 617
Stony Brook, New York 11790

B. STITE MATERIALS ON FILE

A small informal collection of materials relevant to STITE is maintained for reference purposes. The following list of holdings has been distributed to project staff and this list will be supplemented as new materials are added.

1. Application of Aerospace Technology in Industry; A Technology Transfer Profile; Visual Display Systems. Contract NASW-2362. NASA, Technology Utilization Office, 1972. 93 pp.

2. Banathy, B. H. "Information Systems for Curriculum Planning." Educational Technology 10:25-28 (November, 1970)

3. Berk, Alfred M., and Richard Ballard. "Computer Graphics and Physics Teaching." Proceedings of the 1972 Conference on Computers in Undergraduate Curricula 3:409-416 (1972)

4. Bitzer, D. L., Bruce Arne Sherwood, and Paul Tinczar. Computer-Based Science Education. Urbana, Illinois, University of Illinois, 1972 25 pp.

5. California, University of. Berkley. The Center for Research and Development in Higher Education. Annual Report, 1969-70. 101 pp.

6. Collet, Lee S. "SIMEX: A Program to Simulate Experience for Teaching and Testing Research Competencies." Journal for the Association for Educational Data Systems 3:10-18 (September, 1969).

7. Collins, Ronald W. "Computer-Aided Classroom Chemistry Instruction Via Instantaneous Video Projection of Teletype Output." Proceedings of the 1972 Conference on Computers in Undergraduate Curriculum 3:89-95 (1972).

8. Computer Based Resource Units (packet of 9 items)

9. Dick, Walter and Paul Gallagher. Systems Concepts and Computer-Managed Instruction: An Implementation and Validation Study. Tech Memo No. 32. Tallahassee, Florida, CAI Center, Florida State University, 1971, 14 pp.

10. Farr, Richard S. Knowledge Linkers and the Flow of Educational Information. An Occasional Paper from ERIC at Stanford University, 1969, 14 pp.

11. Crowder, Thomas F. "Teacher Automated Guide (TAG)." Journal of the Association for Educational Data Systems 2:121-134 (March, 1968)

12. Florida State University. Computer Assisted Instruction Center. Division of Instructional Research and Service. Annual Progress Report, January 1, 1971 through December 31, 1971. 45 pp.

13. Georgia, University of. Computer Center. Final Report to the National Science Foundation on Grant GN-851 to Expand the University of Georgia Information Center. Athens, Georgia, University of Georgia, 1972. 189 pp.

14. Georgia, University of. Georgia Information Dissemination Center. Profile Coding and Management Manual for the University of Georgia Text Search System. Athens, Georgia, University of Georgia, no date 57+ pp.

15. Georgia University of. Information Services Computer Center. UGA Text Search System. Athens, Georgia, University of Georgia, 1971. Unpaged.

16. Graham, Darol, Guenter Schwartz, and Duncan Hansen. Multi-Media Simulation of Laboratory Experiments in A Basic Physics Lesson on Magnetism. Tech Memo No. 25. Tallahassee, Florida, CAI Center, Florida State University, 1970. 53 pp.

17. Hagerty, Nancy K. Development and Implementation of A Computer-Managed Instruction System in Graduate Training. Tech Report No. 11. Tallahassee, Florida, CAI Center, Florida State University, 1970 159 pp.

18. Hansen, Duncan. Development Processes in CAI Problems, Techniques, and Implications. Tech Memo No. 11. Tallahassee, Florida. CAI Center, Florida State University, 1969. 28 pp.

19. Hansen, Duncan N., Paul C. Manning, and Barbara F. Johnson. A Systematic Approach to Learning Simulations. Tech Memo No. 54. Tallahassee, Florida, CAI Center, Florida State University, 1972. 63 pp.

20. Hansen, Duncan N., Walter Dick, and Henry T. Lippert. Research and Implementation of Collegiate Instruction Of Physics Via Computer Assisted Instruction. Technical Report No. 3 (Final). Vol. I. Tallahassee, Florida, Florida State University 1968. 137 pp.

21. Hansen, Duncan N., Walter Dick, and Henry T. Lippert Research and Implementation of Collegiate Instruction of Physics Via Computer Assisted Instruction. Technical Report No. 3 (Final). Vol. III. Tallahassee, Florida, CAI Center, Florida State University, 1968. 302 pp.

22. Heller, Terry S., John S. Gilmore, and Theodore D. Browne Technology Transfer-A Selected Bibliography. Revised Edition, NASA Report CR-1724. Washington, D. C., National Aeronautics and Space Admin. 1971. 174 pp.

23. Hobson, Edward Newton, Empirical Development of A Computer-Managed Instruction System for the Florida State University Model for the Preparation of Elementary School Teachers. Tech Report No. 3. Tallahassee, Florida, CAI Center, Florida State University, 1970. 124 pp.

24. Holt, Anatol W. Information System Theory Project. Princeton, N. J., Applied Date Research Incorporated, 1968. 352 pp.

25. Jernigan, William W. "One Who DAIRed -- A Dial Access System." Wilson Library Bulletin 44:653-657 (February, 1970).

26. Johnson, Barbara. Systematic Approaches to the Development of Instruction for Adult Basic Education: The FSV Training Model and the Computer-Assisted Reading Model. Tech Memo No. 53. Tallahassee, Florida, CAI Center, Florida State University, 1972. 46 pp.

27. Kochen, M., and L. Uhr. "A Model for the Process of Learning to Understand". In Kochen, Manfred, ed., Some Problems in Information Sciences. New York, The Scarecrow Press, 1965. p. 94-104.

28. Kromhout, Ara M. Effect of Computer Tutorial Review Lessons on Exam Performance in Introductory College Physics. Tech Memo No. 64, Tallahassee, Florida, CAI Center, Florida State University, 1972. 27 pp.

29. Lipe, James Gary. The Development and Implementation Of A Model For The Design of Individual and Instruction at the University Level. Tech Report No. 15. Tallahassee, Florida, CAI Center, Florida State University, 1970. 196 pp.

30. Lyman, Elizabeth R. A Summary of PLATO Curriculum and Research Materials. Urbana, Illinois, University of Illinois, 1972. 47 pp.

31. McAlpine, A., R. D. Whitley, and P. A. Frost. The Flow and Use of Scientific Information in University Research. OSTO Report 8138. 1972. 43 pp.

32. Maron, M. E., A. J. Humphrey, and J. C. Meredith. An Information Processing Laboratory for Education and Research in Library Science: Phase I. Interim Report, Project No. 7 - 1085. Washington, D. C., U. S. Dept. of Health, Education and Welfare, 1969. 150 pp.

33. The NASA Scientific and Technical Information System... And How to Use It. NASA pamphlet, 1972. 25 pp.

34. National Medical Audiovisual Center Catalog. Section I and Supplement. 16 MM Motion Pictures. U. S. Department of Health, Education, and Welfare. (1972) 66 pp. and 5 pp.

35. National Medical Audiovisual Center Catalog. Section II. Videotapes. Supplement No. 1. U. S. Dept. of Health, Education and Welfare, 1972. 5 pp.

36. National Medical Audiovisual Center. Instructional Development Unit; A Guide to Organizing An Instructional Development Unit In Health Science Educational Institutions, by James S. Waldron. U. S. Dept. of Health, Education and Welfare, 23 pp. no date.

37. National Medical Audiovisual Center (packet of 4 items on equipment and techniques)

38. National Medical Audiovisual Center. Toward Improved Learning; A Collection of Significant Reprints for the Medical Educator. U. S. Department of Health, Education and Welfare. Vol. I - 1967. Vol. II - 1969.

39. Sheldon, John W. Computer Assisted Instruction In Engineering Dynamics. Tech. Memo No. 18 Tallahassee, Florida, CAI Center, Florida State University, 1970. 8 pp.

40. Slamecka, Vladimir, Alton P. Jensen and Pranas Zunde. "An Audiographic Repository of Knowledge for Conversational Learning." Reprint from Educational Technology 1971. 6 pp.

41. Smith, Stephen F., and William Harrelson. TMS: A Terminal Monitor System for Information Processing. Final Report. Project No. 7-1085. Washington, D. C., Office of Education, U. S. Dept. of Health, Education, and Welfare. 1971. 139 pp.

42. Stifle, Jack, The Plato IV Student Terminal. Urbana, Illinois, University of Illinois, 1973. 25 pp.

43. STITE Progress Report, July, 1973.

44. Summerlin, Lee. A Feasibility Study of Tutorial Type Computer Assisted Instruction in Selected Topics in High School Chemistry. Tech Memo No. 39. Tallahassee, Florida, CAI Center, Florida State University, 1971. 31 pp.

45. Suppes, Patrick. "The Uses of Computers In Education." Scientific American 215:206-220 (September, 1966).

46. Tuckman, Bruce W., and Keith J. Edwards. "Systems Model for Instructional Design and Management." Educational Technology 11:21-26 (September, 1971.)

47. Wagner, Arthur, and R. Bleed. "Using A Computer to Support the Testing Program in Audio-Tutorial Biology." Proceedings of the 1972 Conference on Computers in Undergraduate Curricula 3:195-1[illegible] (1972).

48. What NASA/RECON Can Do For You; A Computerized Information System At Your Fingertips. NASA pamphlet, 1970. 12 pp.