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ABSTRACT

The Uniterm system of coordinate indexing, developed by the Armed Services Technical Information Agency, provides a method for the organization, storage, and retrieval of information. The contents of reports are analyzed, and terms are assigned to the documents. For each term there is a card upon which the accession number of documents assigned that term are entered. Reports may be retrieved by looking up the appropriate term or by comparing the document numbers on two or more term cards. Thus, the identical numbers appearing on the three cards "air" and "ducts" and "icing" would lead to documents on air duct icing. The document may then be retrieved directly, or a card containing bibliographic information, abstract, and uniterms may be consulted. Rules and directions for indexing and posting are given, along with some references and search methods. (LS)

ARMED SERVICES TECHNICAL INFORMATION AGENCY

INSTALLATION MANUAL FOR THE *Uniterm* SYSTEM OF COORDINATE INDEXING

OCTOBER 1953

PUBLISHED BY DOCUMENT SERVICE CENTER
KNOTT BUILDING, DAYTON 2, OHIO

THE ARMED SERVICES TECHNICAL INFORMATION AGENCY

INSTALLATION MANUAL

for the

UNITERM SYSTEM OF COORDINATE INDEXING

Prepared by Documentation Incorporated
under Contract AF 18(600)-376

OCTOBER 1953

Published by:

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Knott Building
Dayton 2, Ohio

Introduction

The Uniterm System of Coordinate Indexing is a scientifically developed, simple and efficient method for the organization, storage and retrieval of information. Essentially it consists of analyzing the contents of reports into a basic vocabulary together with a method of retrieving their contents by any element or combination of elements in the vocabulary. As a result, it provides a degree of search effectiveness unobtainable through conventional library catalogs. The System was developed under an intensive research program conducted by Documentation Incorporated for the Armed Services Technical Information Agency (ASTIA).

The features of compactness, flexibility, economy of installation, ease of maintenance and ease of searching make the Uniterm System especially suitable for the control of technical documents whose full subject content is frequently lost because of difficulty in gaining catalog control through conventional means. The advantages of the System are derived from the simple principles which are introduced in the following pages.

CONTENTS

Additional copies of this manual may be obtained from ASTIA Document Service Center, Knott Building, Dayton 2, Ohio.

SECTION I

GENERAL DESCRIPTION

Language is based on words. Many ideas and concepts are expressed in language as combination of words. The number of such combinations for any body of information may be large, but the number of individual vocabulary terms used is often surprisingly small. For example, the number of chemical elements is small compared to the number of compounds.

In the Uniterm System of Coordinate Indexing, the information contained in a collection of documents is analyzed into the simplest practical word units of information -- hence, "Uniterm". Each Uniterm is assigned a separate card. Each document is assigned a serial number, and the number is posted on all cards headed by the Uniterms by which the document has been analyzed. The word units usually consist of single-word ideas or concepts, each of which is associated with a body of related information.

For example, the word "air" is associated with a number of different ideas in the phrases, "air ducts", "air speed", "cold air", etc. There are two ideas or terms in the phrase, "air ducts" -- one the class of air ideas, and the other the class of duct ideas. When we use the two terms together, we perform the operation known as logical conjunction. This means simply the combination of "air" and "ducts", and it is obvious that the same concept can be expressed as "ducts" and "air". Thus the order of terms is immaterial since the same total body of information is represented by either arrangement as in the following diagram:

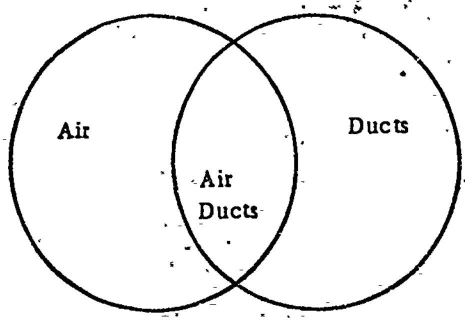


Figure 1.

The overlapping or common area of "air" and "ducts" represents a smaller body of information than either of the individual areas. It is easy to see that a more specific area can be obtained by using a larger number of terms in conjunction, thus narrowing the field of search as in the following diagram:

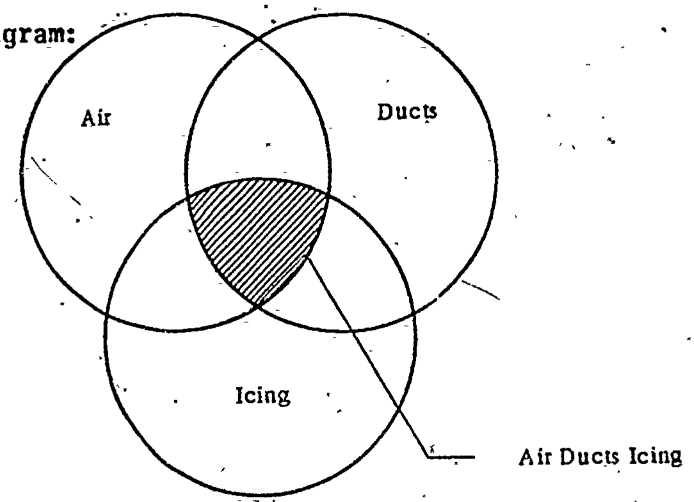


Figure 2.

Since the same logical conjunction is obtained regardless of the order of the terms, the three separate unit terms, "air", "ducts", and "icing", when coordinated, are equivalent to the six possible ways by which this information can be represented in conventional indexing systems:

AIR DUCTS - ICING

DUCTS, AIR - ICING

ICING - AIR DUCTS

ICING - DUCTS, AIR

AIR - ICING - DUCTS

DUCTS - ICING - AIR

Simplicity of Catalog Form

In the manual Uniterm System, as explained in detail in the following pages, this logical conjunction is achieved by searching for the document numbers which are common to two or more Uniterm cards. There is no reason to assume that "air" is any more important than "ducts" or "icing" and consequently no reason to subordinate any one term with respect to any other term as is done in conventional systems of indexing and classification. The making of such assumptions at different times for different cases gives rise to elaborate cross reference structures of such steadily increasing complexity that the conventional systemseventually either become meaningless or make extreme demands upon personnel staffs in maintaining the systems' integrity. By its planned indifference to the order of words, the Uniterm System eliminates the need for conventional cross references.

Economy of Catalog Space

Because of the elimination of permutations and combinations of basic ideas used in most present-day systems, a dramatic saving in catalog space results from the use of the Uniterm System. The size of the System is a function of the number of vocabulary terms rather than of the number of expressions of ideas generated by the combination of terms. For a collection the size of ASTIA's, this reduction of catalog size is in the order of 90%.

After a body of information has been analyzed into the basic ideas or Uniterms, the number of terms increases very slowly as the system grows. However, the number of permutations and combinations of these new basic terms increases rapidly and exponentially, in fact by (2^n-1), where n is the number of Uniterms.

Operational Benefits

The indexer is the first to benefit from the elimination of the permutations and combinations of words found in conventional systems. Freed from the time-consuming necessity of making subjective decisions concerning the order of words and of creating complicated and highly specific indexing phrases and cross references, he assigns Uniterms rapidly and liberally, laying the foundation for a depth of analysis hitherto impractical. The poster, who transfers numbers to Uniterm cards, benefits because his task is simple compared to the corresponding work of preparing and filing full catalog cards for each assignment in a conventional system. The searcher benefits because he can address the coordinate index from any point of view because he can be as specific or as general as he wishes and because he need not wonder about the form of expression used by the indexer.

Manual and Machine Manipulation

The logical fragmentation of catalog elements inherent in the Uniterm System makes retrieval of information possible by machine or manual methods. Currently under development is a machine which will permit random filing and retrieval of Uniterm cards for posting and searching. Also being developed is a completely automatic indexing machine which will present the document numbers in answer to reference questions typed out on a conventional typewriter keyboard.

While the magnitude of the overall problem of information control made the need for machine systems apparent many years ago, the search for a manual method was renewed with the realization that there are many small installations in need of an improved manual method of information control.

Physical Appearance

The Uniterm System in its manual form uses cards of any convenient size, such as 3" x 5", 4" x 6", or 5" x 8", in conventional catalog card trays, visible index files, or looseleaf volumes. The cards have spaces at top and bottom for the Uniterms and are divided vertically into ten columns, numbered from zero through nine, in which document accession numbers are posted. The columnar arrangement is designed simply to break up the mass of numbers posted on the cards. The Uniterm card* looks like this in use:

*Uniterm cards can be printed locally by the user, or, as a matter of information, they can be obtained from Documentation Incorporated, 2521 Connecticut Avenue, N. W., Washington 8, D. C. at a cost of $15.00 per thousand for the recommended 5" x 8" size.

TERM Ducts

0	1	2	3	4	5	6	7	8	9
	11	32	103	24	75	206	37	98	
	61	122	113	34	355	216	47	208	
		312	643		755	826	447		
					785				

Note that the last digit of each serial accession number corresponds to the number of the column in which it is posted. Note also that since documents are cataloged in order of their serial accession numbers, no space need be left in any column, since new documents will always bear a higher number than any number previously posted.

UNITERM card © DOCUMENTATION Incorporated

TERM

Figure 3.

Ease of Search

To demonstrate the simple practice of logical conjunction of Uniterms to find reference to wanted information, the following sample cards correspond to the "air", "duct", "icing" example described in Figure 1 and 2 on page 2.

TERM Air

0	1	2	3	4	5	6	7	8	9
110	11	362	13	14	55	186	77		39
230	421	372	73	34	135	216	327		189
		882	133	454	735	576	447		199
				624	785		677		219

TERM Ducts

0	1	2	3	4	5	6	7	8	9
230	11	32	103	24	75	206	37	98	
	61	122	115	34	355	216	47	203	
		312	643		755	826	447		
		882			785				

TERM Icing

0	1	2	3	4	5	6	7	8	9
230	61	112	93	14	35	216	87		
410	421	312	133	434	425				
	721	372	143	554	785				
		882		674					

UNITERM card — © DOCUMENTATION Incorporated

TERM

Figure 4.

It is indicated here that in our body of literature there are twenty-four documents containing information on "ducts"; twenty-nine on "air"; and twenty-one on "icing". Some of the "duct" information may be on gas ducts, water ducts, and air ducts. We are concerned with finding those having to do with "air ducts icing". The essence of any successful search is to narrow the field of search. Thus, as in Fig. 1, the area of overlap of duct and air information defining that on "air ducts" is determined by the numbers common to both Uniterm cards. The arrangement of numbers by final digits and in ascending order makes it easy to determine that document numbers 230, 11, 882, 34, 785, 216, and 447 pertain to "air ducts". The field of search is already narrowed to seven documents. By comparing these seven document numbers with the numbers on the "icing" Uniterm card, it is determined the four documents (numbers 230, 882, 785, and 216) contain information on "air ducts icing" (see Figure 2).

Basic Factors for Ease of Search

There are several factors which contribute to the ease of retrieving information from the Uniterm System of Coordinate Indexing. The index headings are chosen and recorded as simple "Uniterms"; the documents are identified in the simplest manner - by serial accession number; the numbers are recorded in ascending order on Uniterm cards. Retrieval of information is likewise accomplished in the simplest manner - by visual determination of numbers common to two or more Uniterm cards and by rapidly narrowing the field of search with each comparison made. It will be noted that the time of search is determined by the smallest group of numbers to be compared.

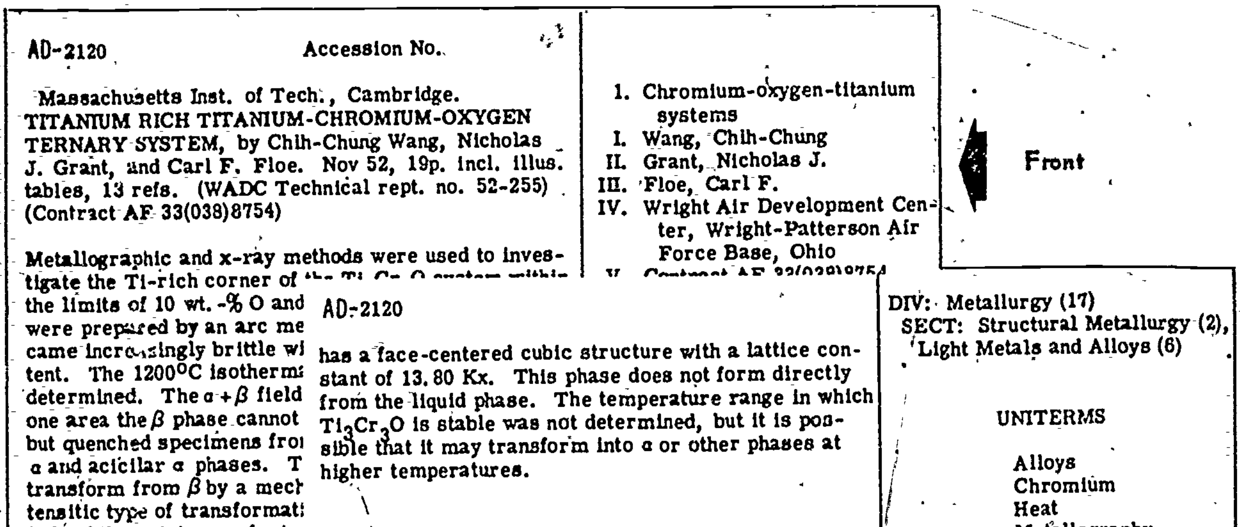
The foregoing operation, known as logical conjunction, is the reversal of the process of fragmentation which occurred when the Uniterms were assigned. It can be seen readily that reference questions involving search technique by alternation or negation (such as either "air" or "ducts" or both; or all documents on "icing" with the exception of "ducts") can be handled with equal facility.

SECTION II

UNITERM INDEXING WITH ASTIA CARDS

For those users of ASTIA services who may wish to adopt the Uniterm System in controlling ASTIA materials, Uniterm tracings will be included on regular ASTIA catalog cards in addition to conventional headings. This manual gives instructions for the installation and use of the Uniterm System utilizing ASTIA cards as document references. Additional instructions are presented so that non-ASTIA material can be processed to provide an integrated file of holdings.

Beginning with ASTIA document number 15001, ASTIA catalog cards will contain Uniterm tracings on the reverse side of the card. These cards will look like this:


AD-2120 Accession No.

Massachusetts Inst. of Tech., Cambridge.
TITANIUM RICH TITANIUM-CHROMIUM-OXYGEN TERNARY SYSTEM, by Chih-Chung Wang, Nicholas J. Grant, and Carl F. Floe. Nov 52, 19p. incl. illus. tables, 13 refs. (WADC Technical rept. no. 52-255) (Contract AF 33(038)8754)

Metallographic and x-ray methods were used to investigate the Ti-rich corner of the Ti-Cr-O system within the limits of 10 wt.-% O and ... were prepared by an arc me... came increasingly brittle wi... tent. The 1200°C isotherm... determined. The α+β field... one area the β phase cannot... but quenched specimens fro... α and acicular α phases. T... transform from β by a mech... tensitic type of transformati... firmed the existence of a te...

1. Chromium-oxygen-titanium systems
I. Wang, Chih-Chung
II. Grant, Nicholas J.
III. Floe, Carl F.
IV. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio

Front

AD-2120

has a face-centered cubic structure with a lattice constant of 13.80 Kx. This phase does not form directly from the liquid phase. The temperature range in which Ti_3Cr_3O is stable was not determined, but it is possible that it may transform into α or other phases at higher temperatures.

DIV: Metallurgy (17)
SECT: Structural Metallurgy (2), Light Metals and Alloys (6)

UNITERMS

Alloys
Chromium
Heat
Metallography
Oxygen
Phase
Preparation
System
Ternary
Titanium
Treatment
X-Ray

Back

Figure 5

These cards differ from earlier ASTIA cards in two respects:

1. A space is provided immediately following the AD number for the serial accession number to be assigned by the user.

2. Uniterm tracings are provided in the right margin on the reverse of the cards; they represent ASTIA's Uniterm subject analysis of the document.

Catalog cards produced by the user or by any other activity, such as the Atomic Energy Commission, the National Advisory Committee for Aeronautics, and the Library of Congress, can be integrated with ASTIA cards by assigning each card its own accession number. Any activity starting a coordinate index should assign number 1 to the first card placed in the accessions file, number 2 to the second card, number 3 to the third card, and so on, regardless of the ASTIA document number or document numbers of any other card-producing agency.

It is recommended that all the materials covered in a single integrated Uniterm System be stored in order by the serial accession numbers assigned by each user in which event the accessions file serves also as the shelflist. If the materials must be filed in some other order, such as by source, subject classification, ASTIA number, etc., location symbols must be shown on the cards in the accessions file; the need for shelflists for other arrangements must be decided without reference to the Uniterm System. Cards can be added to the accessions file without adding the materials to the collection, for subject headings and classification numbers can be converted easily to Uniterms without reference to the materials, especially when titles and abstracts are used to aid in the conversion.

SECTION III

INDEXING AND POSTING

The rules of the Uniterm System of Coordinate Indexing are given in Section IV of this manual. These fifteen rules should be studied carefully by those engaged in both indexing and posting. It is always desirable, of course, for searchers to be familiar with the rules even though they not be regular reference workers.

Indexing

Actually, the indexer is concerned primarily with Rules 1 and 2 which simply tell him to determine the key words representing the subject content of the document and how to record these key words for posting. The indexer is not required to create and maintain a list of approved Uniterms, for such a list is created and maintained as the coordinate index itself. Only rarely does the indexer find it necessary to consult the coordinate index as he assigns Uniterms to the accessioned materials. Consequently, there is a great freedom in amending the vocabulary to describe the changing characteristics of a field as reflected in its literature and to continually enhance the effectiveness of the coordinate index without altering previous entries or the structure of the index. These features, plus the simplicity of the rules, make the indexing operation much more rapid and efficient with the Uniterm System than with any other method.

Posting

The posting of serial accession numbers on Uniterm cards is equivalent to preparing and filing cards in conventional catalogs. In both systems care must be exercised to achieve accuracy. The posting operation is the tedious part of maintaining a Uniterm System, although experience has demonstrated that with proper organization of the work it is less tedious and more economical than card preparation and filing.

The poster has but one major decision to make: that is, whether a term is "free" or "bound" when it is used in the filing position. Rules 3, 4, and 5 in Section IV govern this determination. Generally speaking, words susceptible to combination with other terms in a system are "free" and those found in combination with only one other word in the system are "bound". Bound terms tend to become free terms as a system grows. Therefore, most ASTIA Uniterms will be free terms.

The poster will also be concerned with word form, i.e., singular or plural, substantive or attributive, synonymous and homonymous, etc. Rules 6 through 15 cover these points.

Neatness and accuracy are very important in posting. Careful hand numbering or typing may be satisfactory. Ring-style rubber stemps and numbering machines with repeat settings minimize transcription errors. Small adding or bookkeeping machines may be most satisfactory for large installations, for they can be secured with repeat settings, horizontal tabulation for the columns, easy vertical alignment for the lines, and carriages to suit the width of card; and they produce legible results rapidly.

The Uniterm System of Coordinate Indexing is adaptable to a great variety of conditions. In the places where coordinate indexes are now in operation, no two exactly resemble each other. Because an index is literally tailored to the information collection of each organization, "free" terms in one vocabulary are not "free" terms in another, and so with phrases and inversions. Some include authors' surnames; others do not.

Growth of Uniterm Vocabulary

It is useful to know what to expect during the early growth of a coordinate index. Experience has shown that the number of new Uniterms grows rapidly at the beginning and can be expected to exceed the number of documents indexed. At some point, perhaps between 1000 and 3000 documents, the number of documents equals the number of Uniterms and soon exceeds the number of Uniterms, since the vocabulary is stabilizing at a slow rate of growth. Therefore, in the very early phases of Uniterm systems there are fewer cards than documents, whereas the reverse is true in the case of the conventional subject heading or a classified catalog.

Since an average of eight Uniterms may be assigned to each document, the growth in assignments may reach many times the growth in Uniterms. Figure 6 shows the growth of Uniterms and Uniterm assignments for a collection of 3000 documents.

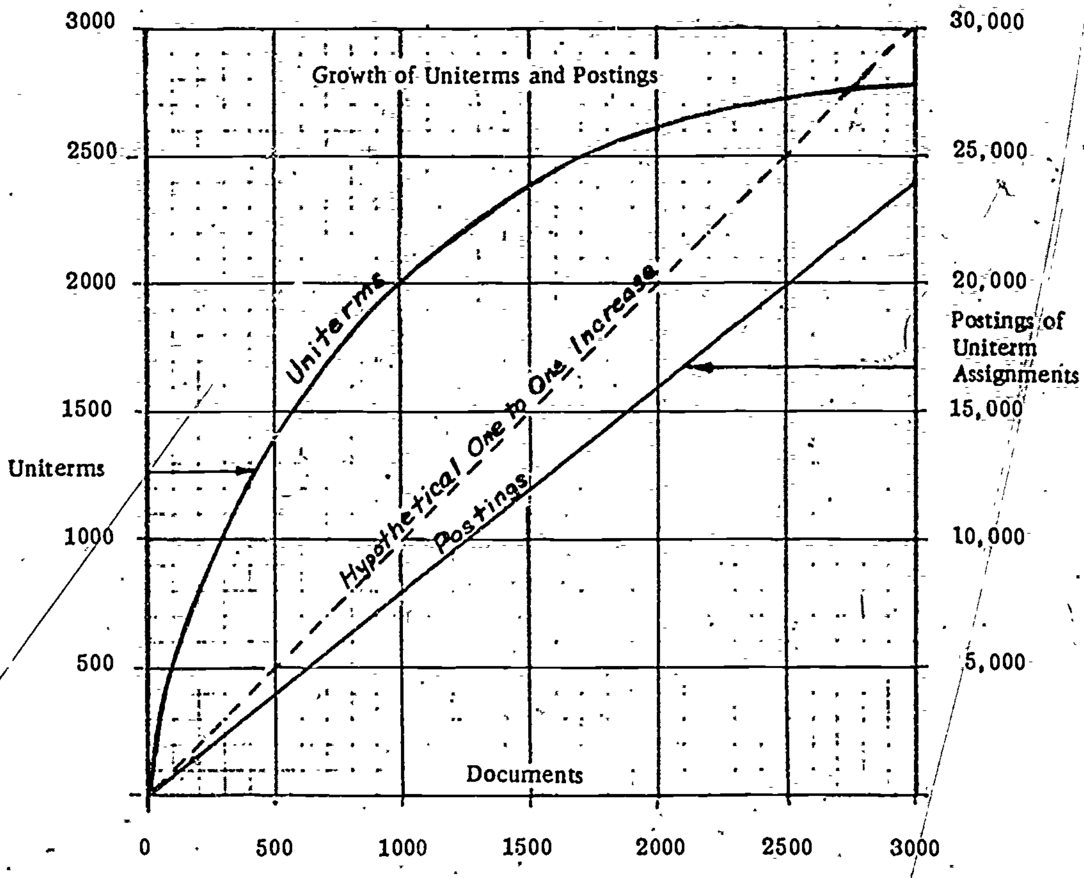


Figure 6.

Any installation can compare its experience with this graph by plotting a cumulative record of its new Uniterms and assignments against the number of documents indexed.

SECTION IV

RULES OF COORDINATE INDEXING

1. **Determine the key words which represent the subject content of the item being indexed.**

Key words are not limited to single common words in the English dictionary. They include phrases, Arabic numerals, alphabetical characters, model and project numbers, such as AN/ARN-5 and MX-772, in addition to the nouns, adjectives, gerunds, participles, and proper names which make up the bulk of any Uniterm vocabulary.

2. **Record the key words on the serial accessions card so that every retrieval word is a filing word in the posting operation.**

This is accomplished by putting every word in a phrase in the filing position; thus, if the phrase "gas turbines" is to be used, "turbines" must be recorded in the filing position as well as "gas". The poster then ascertains whether the "turbines" card in this situation bears the single word, "turbines", or must include "gas" and consequently read, "turbines, gas"; also whether the "gas" card bears the single word or the phrase, "gas-turbines" (see Rules 3, 4, and 5).

NOTE: A few words are not considered to be retrieval words and need not be recorded on the serial accessions cards in the filing position. Examples are: "Effects" and "Methods".

3. If a word is used alone as an indexing term, it is called a "free" term. Enter it as a single word on a Uniterm card.

In the case of a document on "Helium in Air Turbines for Gasoline Pumps", "helium" is a "free term". By virtue of being used alone once, it remains a "free" term in the future and may not be used later in the vocabulary as part of a phrase.

4. If a word in the filing position is used with only one other word in the vocabulary, it is a "bound" or "not free" term. Enter each word of a two-word phrase on a separate Uniterm card in the filing position, and add the other word if the first word is a "bound" term.

Using the example in Rule 3, when the poster considers the phrase "air turbines", there are only three Uniterms in the vocabulary: "helium", "air", and "turbines". Since both words of the phrases fit this Rule number 4, "air turbines" is typed on one card and "turbines, air" is typed on another.

5. If a word occurs in the system in combination with two or more words, it is a "free" term. Enter it as a single word on a Uniterm card.

Referring to the example in Rules 3 and 4, the above situation occurs when the poster is ready to add "centrifugal", "gasoline" and "pumps" to the vocabulary. "Pumps" is a "free" term because it occurs in combination with "centrifugal" and "gasoline" but the "centrifugal" card is typed as "centrifugal pumps", and the "gasoline" card as "gasoline pump" in accordance with Rule 4. Note that the first word, the word in the filing position, is the one to consider whether "bound" or "free". "Pumps" is a free term in the filing position, but it is added to "centrifugal" and "gasoline" because there is nothing on the subject of centrifugal in the system except centrifugal pumps, and nothing related to gasoline except gasoline pumps. "Free" terms and "bound" terms can be added freely to "bound" terms, but no terms can be added to "free" terms.

NOTE: As the posting is continued, always in serial number order, more terms are added to the vocabulary and actual associations of words increase rapidly in the system. The effect of Rules 3, 4, and 5 is to "free" most of the terms, so that a coordinate index for several thousand items soon has single words for the majority of Uniterms. If, following the example used above, a report on "air ducts" enters the system, the poster must "free" the word "air" according to Rule 5, because it is associated with "turbines" as well as "ducts". The operation is the simple erasure of "turbines" from the "air turbines" card. Note that the serial numbers are not disturbed when a phrase is shortened to a "free" term.

6. Enter substantive forms in the plural only, provided the singular can be inferred conveniently without broad change of meaning.

Example: Grasses

7. Enter singular forms after plurals where the appearance of both terms facilitates indexing and searching.

Example: Supplies; Supply

8. Enter the singular form of foreign words and add the plural,

Example: Fungus; Fungi
Spectrum; Spectra

9. If the singular form is broadly generic or defines a field and the plural is more substantive, enter the singular and add the plural.

Example: Temperature; Temperatures

10. Add attributive or adjectival forms to the substantive words with which they stand in the closest sense relationship.

Example: Geophysics; Geophysical

Sun; Solar

Hydrostats; Hydrostatic

11. Enter gerundive forms and add the participles.

Example: Sintering; Sintered

Printing; Printed

NOTE: The form of the endings of words (singular, plural, nominative, etc.) does not affect the filing order as in conventional systems, since each word appears only once in the filing position.

12. Consider the first word of proper names and foreign phrases to be a "bound" term and enter the full phrase.

Example: Black Sea

Clostridium botulinum *

Clostridium perfringens *

* (No entries are made for the second word here)

13. Enter accepted chemical terms occurring as one word in the form in which they appear.

Example: Amines

Phenylamines

Diphenylamines

Nitrodiphenylamines

14. Where true synonyms occur, enter the well-known form and make a see reference from the other form.

Example: Petrol see Gasoline

Since the see references are consulted rarely, they may be kept conveniently in another file.

15. Enter homonyms as one Uniterm. Where meaning may prove to be unclear in coordination, show meanings parenthetically on separate cards, particularly where many serial numbers are involved.

Example: Pitch (substance)

Pitch (motion)

Pitch (acoustics)

Pitch (angle)

SECTION V

REFERENCE WORK WITH A COORDINATE INDEX

The visual reference use, or searching, of a coordinate index consists of comparing two or more Uniterm cards to determine numbers common to the cards. The common numbers denote the area of logical conjunction of the elements of the question.

It was explained in Section III that because of the size of the ASTIA collection, most Uniterms on ASTIA cards will be "free" terms. However, many ASTIA users will find that ASTIA "free" terms might properly be "bound" terms in their particular systems in view of their specialized interests. If a search shows that all numbers on the "air" card are common to those on the "duct" card, the Uniterms can be changed to "air ducts" and "ducts, air". The change makes it unnecessary to coordinate again under similar circumstances, for either card shows at a glance that "air" and "duct" are bound terms.

For a variety of reasons, reference workers may wish to prepare a record on cards or slips of all coordinations made for searchers. This record serves as:

1. Call slips for documents and for abstracts to be consulted.
2. A file of answers for cases where frequent coordination of the same terms are made, thus making the repetitious coordination of the same terms unnecessary.
3. A source for frequent tabulations to show the volume and kind of reference work which has been performed, thus providing a record not available in most libraries.

TERM:

0	1	2	3	4	5	6	7	8	9

DOCUMENT RESUME

ED 108 665 IR 002 191

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DESCRIPTORS Class Size; College Students; Cost Effectiveness; Course Evaluation; Dropout Rate; Engineering Education; Grades (Scholastic); *Higher Education; *Individualized Instruction; *Individualized Programs; *Program Evaluation; Retention; Study Habits; Teaching Methods
IDENTIFIERS Alfred P Sloan Foundation; Keller Plan; *Personalized System of Instruction; PSI; University of Texas

ABSTRACT

Progress on the University of Texas personalized system of instruction (PSI) project is described. Twelve courses in the College of Engineering and five in other colleges were developed for PSI under a grant from the Alfred P. Sloan Foundation. Each of those courses has now been offered at least once, thus making it possible to begin evaluating the program. Nine questions on the effectiveness, efficiency, student and faculty acceptance, and longer term utility of PSI are discussed. (DGC)

Seventeen PSI Projects at The University of Texas at Austin

by

James E. Stice

This is a progress report on the PSI project at The University of Texas at Austin, sponsored by a grant from the Alfred P. Sloan Foundation. Under this grant 17 PSI courses were developed by the Associate Investigators, 12 of them in the College of Engineering and five in other colleges. The Associate Investigators and the course each developed are:

1. Structural Dynamics - Roy R. Craig, Assistant Professor, Department of Aerospace Engineering and Engineering Mechanics
2. Design of Structural Systems in Timber - David W. Fowler, Associate Professor, Department of Architectural Engineering
3. Process Analysis and Simulation - David M. Himmelblau, Professor, Department of Chemical Engineering
4. Electrical Engineering Laboratory I - Charles H. Roth, Jr., Professor, Department of Electrical Engineering
5. Electrical Engineering Materials - H. Lyndon Taylor, Associate Professor, Department of Electrical Engineering
6. Introduction to Engineering Analysis - Nancy S. Hamilton, Instructor, Department of Mechanical Engineering
7. Introduction to Nuclear Reactor Theory - Billy V. Koen, Associate Professor, Department of Mechanical Engineering
8. Dynamic Systems Synthesis - Lawrence L. Hoberock, Assistant Professor, Department of Mechanical Engineering
9. Engineering Statics - Wallace T. Fowler, Associate Professor, and Paul E. Nacozy, Assistant Professor, Department of Aerospace Engineering and Engineering Mechanics
10. Engineering Economics - William G. Lesso, Professor, Department of Mechanical Engineering
11. Introduction to Operations Research - Charles S. Beightler, Professor, Department of Mechanical Engineering
12. Probability and Statistics for Engineers - Gerald R. Wagner, Assistant Professor, Department of Mechanical Engineering

13. Basic Cataloging and Classification - Billie Grace Herring, Assistant Professor, Graduate School of Library Science

14. Freshman English Composition - Susan W. Wittig, Assistant Professor, Department of English

15. Principles of Chemistry - John M. White, Associate Professor, Department of Chemistry

16. Engineering Physics I - Austin M. Gleeson, Associate Professor, Department of Physics

17. Principles of Audio and Visual Production - Robert D. Brooks, Associate Professor, Department of Radio-TV-Film

Each Associate Investigator developed his course and taught it during one semester, then revised the course in light of the feedback received from proctors and students and offered it for a second time. All courses were supposed to follow the "pure" Keller model. In fact, all did not; many professors injected slight variations, depending upon their own teaching styles and personalities. None of these variations was believed to effect the intent of the project. The final report will discuss these variations in detail.

In addition to the development of courses, the project was to investigate nine questions often asked about the PSI technique. These questions will be individually discussed later in this paper, together with the answers we have obtained from the data received to date.

An Advisory Board was selected to provide assistance and guidance to project personnel during the period of the grant. The permanent members of this Advisory Board were : Dr. David G. Born, Department of Psychology, University of Utah; Dr. Ben A. Green, Jr., Center for Personalized Instruction, Georgetown University; Dr. Fred S. Keller, Washington, D.C.; Dr. David T. Pratt, Department of Mechanical Engineering, University of Washington; Dr. J. Gilmour Sherman, Department of Psychology and Center for Personalized Instruction, Georgetown University. In addition, several people served as temporary members of the Advisory Board because of individual expertise they could contribute to the project. These members were: Dr. Amogene F. DeVaney, Department of Mathematics and Engineering, Amarillo College; Dr. Gerhardt F. Paskusz, Associate Dean of Engineering, University of Houston; Dr. E. Joseph Piel, ECCP Project, State University of New York System; Dr. George T. Semb, Department of Human Development, University of Kansas; and Dr. Bernet S. Swanson, Department of Chemical Engineering, Illinois Institute of Technology.

The project began on January 1, 1973 and will terminate December 31, 1975. The questions which we hoped to answer during the course of the project, together with the tenative answers derived from the data analyzed up to this time are:

1. Do students learn more (or better) under the PSI method than under "conventional" methods?

Achievement measures were compared between 11 PSI courses and associated control courses. Students in the PSI courses did significantly better in five of the courses, there was no difference between the two groups in five courses, and the control class did better than the PSI class in one instance. Thus ten out of the eleven classes did as well or better under PSI than under conventional teaching methods.

All achievement measures were final exam data, except in the case of the Engineering Physics I course. In that course there was no significant difference between the PSI physics class and the control class in an advanced placement test devised by the Department of Physics. The motivation was the same for both groups since the Advanced Placement Test results did not effect the grades of either group of students. The statistical analyses were controlled for grade point average, Scholastic Aptitude Test (SAT) verbal score, SAT quantitative score, SAT total score and where applicable the score on the College Entrance Examination Board Level I Mathematics Achievement Test. This was done to remove initial intergroup differences in aptitude or achievement.

PSI undergraduate students in the mid-range of grade point average and with SAT scores of around 1000 tended to do better than similar students in the control courses. Data are limited and are not statistically significant, but there is a definite trend. In the single graduate course (Library Science), students with a graduate record exam verbal score greater than 600 did better than similar students in the control class. The mean graduate record examination verbal score is 500 for this group, so a score of 600 puts a student in the 84th percentile. It thus appears that the better graduate students in the PSI course did better than their peers. Among the undergraduate students the average students in PSI classes did better than their peers in control classes.

2. Are the higher grades obtained in PSI courses justified?

In six out of nine comparisons, the A students in control classes scored significantly higher on the final examinations than the A students in PSI courses. In the other three comparisons there was no significant difference between the groups. In no case did the PSI students do better.

In six comparisons of B students, three control classes had better final exam scores, while in two comparisons there was no significant difference, and in one case the B students in the PSI course did better.

It must be pointed out that there was a significant difference in motivation between the PSI students and students in the control classes. In all cases the students in the control classes received a significant portion of their final grade in the course from their final examination. In many cases the grade on the final examination had no effect on the students in the PSI classes and in no case did the PSI students' final examination grade count more than 25% of his course grade. We are obtaining more data from the Engineering Physics I class this spring. Both the PSI section and the control sections will take the Physics Department Advanced Placement Test which will effect the grade of neither group, thus adjusting for the motivational differences present in the comparisons.

3. Do PSI students exhibit a significantly different long-term retention of course content than students in conventional courses?

We did some follow-up studies of students in both PSI and control classes analyzing the grades of both groups in a course that followed the PSI course. The results were mixed.

The PSI course in engineering statics was first offered during the spring of

1973. Students from both the PSI statics course and the conventional statics course later took Engineering Dynamics and/or Strength of Materials. There was no significant difference on final exam scores between the two groups in the Engineering Dynamics course, but the control group scored higher on the final examination in the course on Strength of Materials. The PSI Engineering Statics course was revised during the summer 1973 and offered again during the fall 1973. There was no significant difference between this PSI group and their associated control group in the final examination scores in either Engineering Dynamics or in Strength of Materials. It appears that the PSI Statics course improved as a result of the revision. However, the students in the control class had a significantly higher portion of A's and a significantly lower proportion of D's in Engineering Dynamics. In Strength of Materials the proportion of A's was approximately the same for both classes, but the control had a significantly lower proportion of D grades.

The graduate course in Library Science was compared with its control group with respect to final examination scores in the course following Basic Cataloging and Classification. There was no significant difference between the two groups.

In Introduction to Engineering Analysis (the pre-calculus mathematics course), PSI students made a significantly higher proportion of A, B, and C grades in the first semester of calculus than did their associated control groups. Also, the control group had 39% D's and F's in the first semester of calculus, while the PSI group had only 9% D's and F's. This result was highly significant (p less than .01).

4. <u>Do students in PSI courses learn how to study?</u>

Freshman and sophomore students were pre-tested with the Brown-Holtzman Survey of Study Habits and Attitudes. At the conclusion of the semester the same test was administered as a post-test. The Brown-Holtzman test has seven sub-scales: study oreintation, study attitudes, study habits, delay avoidance, work methods, teacher approval, and education acceptance. In both spring and fall 1973 there was no significant difference between PSI sections and control sections on the delay avoidance sub-scale pre-test. On the post-test this was significant (p = .07). On the education acceptance sub-scale pre-test differences were insignificant but the post-test difference was highly significant (p = .02), with the PSI students having the higher mean score. These results indicate that PSI students were not as likely to put work off as control students, and that the PSI students were more accepting of educational objectives and practices.

Student objective opinions also were sought to get at an answer to this question. Of 840 students sampled 57% said "Yes" or "Definitely yes", their study habits had improved as a result of PSI. Neutral responses were given by 23%, and 20% said "No" or Definitely no".

5. <u>Can PSI materials developed by a given professor be used at another University with roughly equal results?</u>

Data to answer this question were obtained from a PSI Summer Institute in Statics which was given at the University of Texas at Austin during the summer of 1973. Twenty-two community college and four-year college teachers attended this institute, which lasted for a period of nine weeks. These teachers took the course in Engineering Statics which had been developed in the spring of 1973 by Drs. Fowler and Nacozy. All took the course as students; those who finished early proctored their classmates. When everyone had completed the course, the last several weeks were spent in revising it. During the same period, the teachers received continuing instruction in the PSI method, in writing instructional objectives, methods of testing, and classroom management. The enthusiasm of the participants was high, and all considered the institute to have been very successful.

During the following academic year, 11 of the PSI Institute participants used the materials to teach the course at their schools. The other 11 did not do so for several reasons. Some were not able to get a sufficient enrollment to offer the course at their school; three returned to graduate school themselves, and thus were not actively teaching at the time; two others did not teach the following year. Of the 11 participants who used the materials, all said the transfer was successful. Nine said the materials required little revision for use at their home institutions, and nine said the materials were not too difficult for their students. All 11 said that in their opinion the course improved their students' study habits. The 11 participants who taught a PSI Statics course at their own institutions said they would not have wanted to tackle the job without having attended the PSI Summer Institute, and they thought the nine-week time period was about right - eight weeks would have been a minimum.

The participants who taught the PSI course encountered problems. The teachers from the community colleges were unable to get many proctors, because most students transfered to a senior college after completing their course. All said it was difficult to get money to pay the proctors. Also they reported some of their faculty colleagues complained that the Statics course took too much of the students time. Further, the PSI teachers didn't want to acquire the reputation of being "easy" graders. Finally, there were reports of administrative objections to the large proportion of A grades.

The Summer Institute participants who taught the course at their schools devoted approximately one-fourth as much time to teaching the course as the University of Texas at Austin course developers had invested while developing the course.

The only significant difference between results at the University of Texas at Austin and the results at the other schools, was that the number of students dropping the course was significantly larger at the other schools.

6. <u>What are the costs and instructor time requirements of a PSI course?</u>

Cost data on PSI courses are fairly sparse. Student-proctor ratios averaged 10 to 1 across the 17 courses, ranging from 3 to 1 to 16 to 1. This range caused no significant difference in student attitude toward the courses, as expressed on the Course-Instructor Survey (student course evaluations). The average cost per student for each course (not including the professor's salary) was $35.67, with a range of $16.11 to $73.55. The average cost of supplies, secretarial and clerical costs, and reproduction of materials per course was $5.11, with a range of $.04 to $22.20.

During the first offering of the PSI courses, comparisons were made between nine PSI courses and nine associated control courses. The PSI course developers averaged 24 hours per week, the range being 5 to 50 hours. Faculty teaching control courses averaged 12 hours per week, the range being 6 to 18 hours. During the second offering, only two PSI course developers kept a record of their time expenditure, and the average for these two courses was 10 hours per week.

From these data there is no question that a PSI course takes more time than a traditional course in the first semester it is being developed. The time requirement declines to a reasonable level after the period of initial development.

Instructors were requested to rank-order their activities and the fraction of time devoted to each. During the first offering of the course the activities were ranked:

1. Materials preparation
2. Working with proctors and students
3. Record-keeping
4. PSI-related professional interaction (meetings with PSI project group, meetings with advisory board, discussions with colleagues, and invited papers)

In the second and succeeding offerings less time is required for materials preparation, while the interaction with students increases.

7. What are the various causes of procrastination and can it be minimized?

In order to answer this question, it was first necessary to define "procrastination". Members of the evaluation team defined a procrastinator as one whose early rate of progress is such that his required late rate must be twice his early rate in order to finish all units of the course without taking an incomplete. The early period is defined as the first two-thirds of the total number of class days, and the late period is the last third. This means that a student identified as a procrastinator will be covering the same number of units, or more in the last one-third of the course as he did in the first two-thirds.

Using this definition the following conclusions have been drawn (941 students in the sample):

1. Procrastinators have lower grade point averages and SAT scores than non-procrastinators. Among graduate students there is no difference between procrastinators and non-procrastinators on Graduate Record Examination scores.
2. Freshmen and seniors have the highest procrastination rate. No other significant differences were found for student classification.

3. Students taking six hours of course work or less had a lower procrastination rate than students taking ten hours or more.

4. Numbers of hours worked on outside jobs had no effect on procrastination.

5. Previous experience with PSI courses lowered procrastination rates.

6. Students who have had no previous experience with PSI courses are more likely to procrastinate than students who have had a PSI course before. This result is independent of the experienced students' attitudes toward PSI (positive, neutral, or negative).

7. Procrastination rates dropped from the first offering to the second offering of a course. Instructors explained this by pointing out that revision of their materials improved the course.

8. No relationship was found between proctor/student ratios and proportion of procrastinators in a class.

9. Progress lines had mixed effects on procrastination. The use of deadlines or modules (allowing students to take a test over several units at once) had little if any effect.

10. Procrastination does <u>not</u> indicate less mastery.

11. Procrastination had a direct effect on course grade.

8. <u>PSI courses regularly produce a higher drop out rate than regular courses. Can this rate be reduced and if so, how?</u>

Six comparisons were made between PSI and control classes in the spring of 1973. In two of these comparisons the PSI course had a significantly higher rate of dropouts, but in the other four courses there was no significant difference between PSI courses and control courses. Beginning with the fall semester of 1973 and thereafter, the drop rate in PSI courses has not been higher, and in fact has been lower in <u>every</u> case, but the difference is not statistically significant.

At the beginning of the PSI project our plans were to run the courses in a strict self-paced format, allowing students to take a grade of "Incomplete" and to spend as much as an extra semester to complete their PSI course, if they so desired. As a result, 26% of the students taking PSI courses during the spring of 1973 took a grade of Incomplete at the end of that semester. We soon found out that this created some unanticipated problems. The University of Texas at Austin grading policy scores an Incomplete as 0 grade points for X hours of credit, and so until the grade of incomplete is changed into a final grade, it is scored exactly the same as an F. None of the Associate Investigators on the PSI project knew of this policy, nor did several of the personnel in the Registrar's office. We became aware of it quickly, though, when several good students lost scholarships and others failed to receive invitations to various honor societies because their grade point average was affected.

We quickly changed our policy, and agreed to limit the grade of Incomplete to those cases for which that grade normally would have been employed. Thus our courses were constrained to begin and end on definite dates, although the student's progress within the course was still self-paced. As a result the number of Incomplete grades allowed in the fall semester of 1973 dropped to less than 5%.

It might be mentioned that of the students who received Incompletes in a PSI course 54% completed the course and obtained a final letter grade within one semester.

Personal and telephone interviews were held with 58% of the students who dropped either a PSI course or its matched control course. Students dropping control courses commonly said they weren't doing well in them or were failing. Students dropping the PSI courses all said they had gotten behind. Not one said he was not doing well in the course.

9. What is the effect of class size in PSI courses?

The PSI classes were arbitrarily grouped into "small" classes (10 to 47 students) and "large" classes (65 to 370 students). Students in the small classes tended to react more favorably to PSI on the Course-Instructor Survey, but even students in the large classes were neutral to favorable. No relationship was found between the size of class and the instructor time requirement.

I made a serious blunder when the project began. Every effort was made to keep the various administrators advised about what was going on in their department or in their college with respect to the project. This was done through memos, and I assumed that they were being read and understood. In fact, these administrators were busy people, and although they might have read all this material they didn't necessarily understand it. An attempt to get them together for a one-day workshop failed, because the several people to whom I proposed this idea were unwilling to devote that much time to it. After the project had been in operation for one year, we assembled the deans and department chairmen who had faculty members participating in the project, and they met with the members of our Advisory Board. It quickly became evident that these administrators were not very well informed on what we were doing. It would have been better if I had gotten them together when the project was beginning, even if only for an hour. I would advise anyone who is beginning a PSI course or project in their department to take particular pains to make sure those administrators understand what PSI is, and the way in which it differs from more conventional types of instruction.

The problem with the grade of Incomplete, which has been discussed above, also caused great concern among the project personnel. Since the effects of the university's policy have been recognized, a resolution has been introduced in the Faculty Senate to try to get the policy changed. These recommendations were referred to committee, and no committee recommendation has resulted during the past year. So for the immediate future at least, the PSI courses are allowing the grade of Incomplete only for conventional reasons.

Unusually large enrollments caused complications in at least two of the courses developed in the project. Prior to the fall of 1973 the enrollment in Electrical Engineering Laboratory I had never exceeded 90 students. Thus Dr. Roth made preparations for handling 90 students in his self-paced version of the course, only to be greeted by 118 registrants! By the time the course had begun he was unable to obtain the additional laboratory equipment needed, and he was also unable to obtain additional proctors, as the upperclassmen and graduate students who would have been suitable had accepted other part time employment. He further discovered that although a proctor-to-student ratio of 1 to 10 was satisfactory for a lecture course he had developed earlier, this ratio was not sufficient for a laboratory course, and a ratio of 1 proctor to 6 students was more realistic. His course did not run smoothly during the fall semester. When the course was offered for the second time during the spring of 1974, the new laboratory equipment had been received and installed, and he had arranged for the larger number of proctors needed. Also the enrollment in the course was normal. As a result the second offering was quite successful.

The PSI course in Engineering Physics I was similarly plagued with unusual enrollment: The projected engineering enrollment in this course was about 300 students, who were to be about evenly divided between the PSI section and a section taught by conventional methods. The actual enrollment was about 600 students, requiring two sections taught by conventional methods and a PSI section of 370 students. The unexpected problems with which Dr. Gleeson had to cope included a shortage of textbooks for the first month, a student population in the self-paced laboratory which was very much larger than anticipated, and a shortage of available proctors. The course nevertheless was a success, and during the second offering it is proceeding very smoothly.

I have been very interested in following the fate of the seventeen courses developed in this project when the outside funding disappeared. Although it is rather early to draw any conclusions, indications are that at least twelve of the courses have been assimilated into the various departmental curricula, and will continue to be offered using the PSI format. Three will be taught by PSI when the Associate Investigator developing the course teaches that course, and only two are in the questionable category. The courses which seem to be permanent are: Structural Dynamics (Craig); Design of Structural Systems in Timber (D. Fowler); Process Analysis and Simulation (Himmelblau); Introduction to Engineering Analysis (Hamilton); Introduction to Nuclear Reactor Theory (Koen); Dynamic Systems Synthesis (Hoberock); Engineering Economics (Lesso); Introduction to Operations Research (Beightler); Probability and Statistics for Engineers (Wagner); Freshman English Composition (Wittig); Engineering Physics I (Gleeson); and Principles of Audio and Visual Production (Brooks). The courses which will be taught using PSI when the course developer teaches them include Electrical Engineering Laboratory I (Roth), Principles of Chemistry (White), and Engineering Statics (W. Fowler and Nacozy). Those courses which may not be taught using PSI in the future are Basic Cataloging and Classification (Herring) and Electrical Engineering Materials (Taylor).

Interpretation of the data acquired by the evaluation team continues, and further data are being obtained in the form of follow-up studies. A final project report is in preparation and should be available sometime during the summer of 1975.