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THE DEVELOPMENT OF AN INFORMATION SYSTEM FOR ELEMENTARY SCHOOL MATHEMATICS CURRICULUM MATERIALS--A FEASIBILITY STUDY. FINAL REPORT.

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OBJECTIVES OF THE PENNSYLVANIA RETRIEVAL OF INFORMATION FOR MATHEMATICS EDUCATION SYSTEM (PRIMES) PROJECT WERE TO DEVELOP AN INFORMATION STORAGE AND RETRIEVAL SYSTEM FOR ELEMENTARY SCHOOL MATHEMATICS CURRICULUM MATERIALS AND TO ESTABLISH PROCEDURES FOR LOCAL PENNSYLVANIA SCHOOL DISTRICTS TO USE THE SYSTEM FOR CURRICULUM DEVELOPMENT AND SELECTING INSTRUCTIONAL MATERIALS. BECAUSE BRIEF EXPERIENCE WITH THE SYSTEM PRECLUDES DISCUSSING EFFECTIVENESS, THIS REPORT DESCRIBES THE DEVELOPMENT AND USE OF PRODUCTS. A CENTRAL MICROFILM DOCUMENT FILE, CONSISTING OF 25,000 ANALYZED PAGES FROM ELEMENTARY MATHEMATICS BASAL TEXT SERIES, AND ACCOMPANYING TOOLS, INCLUDING CONTENT AND BEHAVIOR AUTHORITY LISTS, WERE DEVELOPED BY SUBJECT SPECIALISTS AND PREPARED BY COMPUTER. TWO REGIONAL CENTERS WERE ESTABLISHED FOR SERVICE TO LOCAL SCHOOLS, AND PRIMES PERSONNEL HAVE PARTICIPATED IN TEACHER EDUCATION PROGRAMS. EDUCATIONAL CONSULTANTS WHO STUDIED THE OPERATION RECOMMEND THAT THE SYSTEM BE APPLIED AND DATA COLLECTED FOR EVALUATION. CONCLUSIONS ARE THAT (1) ANALYSIS OF MATERIALS CAN BE DONE CENTRALLY BY A STATE EDUCATION AGENCY, (2) IT IS FEASIBLE TO APPLY NEW INFORMATION TECHNOLOGY TO EDUCATIONAL CURRICULUM MATERIALS, AND (3) SERVICE TO LOCAL SCHOOL DISTRICTS SHOULD BE DECENTRALIZED. EXPANDING THIS SYSTEM AND MOVING TO OTHER AREAS AND STATE-WIDE SERVICES ARE SUGGESTED. APPENDIXES LIST PROJECT PERSONNEL, BASAL TEXTBOOK PROGRAMS IN FILE, AND FILE PARAMETERS. (JB)

FINAL REPORT
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November 1967

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

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THE DEVELOPMENT OF AN INFORMATION SYSTEM FOR ELEMENTARY SCHOOL MATHEMATICS CURRICULUM MATERIALS: A FEASIBILITY STUDY

Cooperative Research Project No. 6-8152

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Bureau of General and Academic Education
Bureau of Research Administration and Coordination
Department of Public Instruction
Harrisburg, Pennsylvania

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INTRODUCTION

"The Development of an Information System for Elementary School Mathematics Curriculum Materials: A Feasibility Study," Project No. 6-8152, was partially supported by funds under a Small Projects Proposal submitted to the U. S. Office of Education, Bureau of Research, September 14, 1965, Contract No. OE-6-10-352. The grant was awarded to the Department of Public Instruction, Commonwealth of Pennsylvania, to assist in applying the latest technology of indexing, microfilming, storage, and retrieval to a file of analyzed curriculum materials and to assess the feasibility of using this file with local school districts. The development of the file of information was initiated by Doris E. Creswell, Elementary Mathematics Adviser, and Emanuel Berger, Educational Research Associate, on January 1, 1965. Additional support was provided by the Commonwealth of Pennsylvania, the National Defense Education Act-Title III, and the Elementary and Secondary Education Act-Titles III and V.

THE PROBLEM

Every school district in the Commonwealth of Pennsylvania is faced periodically with the need to select an elementary mathematics text series. This decision usually commits a district to the use of a particular text series for several years and exerts a strong influence on the development of the professional staff. These factors require that a careful selection be made. This involves an analytical study of instructional objectives and the construction of a curriculum guide that reflects these objectives. A consideration of the role of mathematics instruction in the total curriculum, the qualifications of teachers, and the needs of the learners should precede these activities. Textbook selection criteria would have to be developed, the sample books would have to be acquired, and a comprehensive survey of each one would be necessary. Most school districts have neither the time nor the resources to develop curriculum guides and select appropriate instructional materials.

Thus, the selection task confronting each local school district is enormous. Over 30,000 pages of material should be read just to examine the current basal programs. Prior to mathematical and pedagogical assessment, a set of reliable criteria must be developed for curriculum guide construction and textbook selection. Devising such criteria, alone, usually convinces a conscientious administrator that the task exceeds local resources. Frequently,

the available criteria are stated in terms too general for effective program comparison. For example, one criterion published recently by a leading state education agency states:

> The series of texts shall provide for content for each grade which is adapted to the needs, interests, and abilities of pupils.

To apply this guideline, a local committee must develop a list of "needs, interests, and abilities of pupils...for each grade ..." It would then have to examine each program and determine whether or not it satisfies the criterion. The difficulty of the task is further compounded if a district attempts to evaluate 15-20 criteria items, many as comprehensive as the example cited. If these tasks were repeated in each of the Commonwealth's 500 school districts, they would indeed represent an extraordinary, if not prohibitive, investment in man-days and effort.

The technology for analyzing, storing, retrieving, and disseminating large volumes of information has been developed. For instance, the Smithsonian Institute is operating a Science Information Exchange that "... has information about over 40,000 biomedical research projects..." Coverage is being extended to the physical and social sciences. Since considerable experience has been accumulated in working with information problems in other disciplines, it is reasonable to assume that this knowledge will be applicable to curriculum materials; especially since neither the volume of published curriculum materials nor their complexity are as great as the problems encountered when working with scientific information.

The Pennsylvania Retrieval of Information for Mathematics Education System, hereafter referred to as PRIMES, has utilized this modern technology to process the information in twenty published elementary textbook series. A center for this information has been established at the Department of Public Instruction. Each school district in the Commonwealth has access to the information for curriculum decision-making. PRIMES is based on the policy that mathematics curriculum decisions are the responsibility of the local school districts. The System is not intended to recommend specific basal programs for use in the Commonwealth. The purpose of the System is to provide school districts with an auxiliary tool for developing and selecting instructional materials consistent with their own educational aims.

RELATED LITERATURE

Research and development activity in "information storage and retrieval" is comparatively recent. Most studies in this field have been published since 1960. Nevertheless, in this short time, one bibliography cites almost 100 references dealing with applications to social science, medicine, space science, educational research, and library science. (3)

The projects described below are examples of the information problems that are currently being solved. Many of the insights and techniques developed in dealing with published material in a given field are applicable to another field with appropriate modifications.

The "Knowledge Availability Systems Center" at the University of Pittsburgh has assumed the task of determining how aerospace data can best be stored, processed, made readily available, and quickly utilized. Its objective is to analyze more than 3,000 documents on aerospace research that are published each month. Faculty members conversant in engineering, natural sciences, and library science help to interpret the needs of local companies and to pinpoint applicable research findings. Swift computerized searches for relevant information are made through the facilities of the Computation and Data Processing Center at the University. The core of its activities include, on a monthly basis:

1. Updating more than 3,000 documents on current aerospace developments.

2. Abstracting all documents.

3. Compiling a cumulative index to the documents, stored on tape for computer retrieval. (5)

In the field of education, the pioneering efforts of the Center for Documentation and Communication Research at Western Reserve University are especially relevant. In 1961, the U. S. Office of Education contracted with the Center to develop a pilot information service for educational media research applied generally to other areas in educational research. The need for a "system" was convincingly demonstrated by the Science Information Exchange. By early 1963, it had produced abstracts of 686 current research projects in education. A conservative estimate of $20,000 per project, totaling over $1,370,000 for all projects, indicates the measure of the confidence evidenced by the supporters for the basic usefulness of the method. (2)

Analysis and retrieval of biomedical literature is the concern of an ambitious system installed at the National Library of Medicine in Bethesda, Maryland. The system is considered the world's largest collection of journals, books, and monographs in medicine available to physicians, scientists, and medical educators. There are three chief products of MEDLARS (Medical Literature Analysis and Retrieval System):

1. A monthly listing of current biomedical literature, called Index Medicus, consisting of 14,000 references.

2. Bibliographies in such specialized subjects as cancer, heart disease, dentistry, and medical education.

3. Demand bibliographies which result from requests for machine searches of the computer's data files for answers to complex reference questions.

Each day about 700 new articles are processed and entered in the files. The current data base consists of about 450,000 articles. Information is derived from 2,400 journals received at the library from all over the world. (4)

Another application of information retrieval is the project at the University of Pittsburgh where the Pennsylvania statutes and the attorney general's opinions relating to education have been placed on magnetic tape. In addition, all of Pennsylvania statutes, some 75 volumes, have been put onto tape. This information was used to generate a concordance which alphabetized all the words in the library and showed their frequency of occurrence. The system attaches to each word a series of numbers which identifies the exact location in the library where each occurrence of the word appears. By knowledge of the frequency of occurrence of various words and the words representing key concepts in the legal questions, a strategic approach can be developed which will yield a maximum number of valuable documents and keep at a minimum the number of irrelevant or semi-relevant documents retrieved. (1)

PURPOSES

PRIMES proposed to accomplish these objectives:

1. Develop a system for analyzing, storing, and retrieving information related to elementary school mathematics curriculum materials.

2. Develop procedures for utilizing the system for curriculum decision-making by local school districts in

   a. Constructing curriculum guides - An elementary school mathematics curriculum committee can use the file components in determining a scope and sequence of content with suggestions for teaching the content that reflects the philosophy of the local school district.

   b. Selection of a basal textbook series - The file of definitive information on existing published programs can be used by local school districts as an aid in selecting those instructional materials that are most appropriate for implementing their curriculum guide.

   c. Selection of supplementary material - Use of the curriculum file can assist a school district in identifying the content and behaviors for its present text series and locating instructional material containing concepts that are not included. Additional materials can be provided for review work, remedial instruction, a different mode of presentation, and more challenging work for the more able students.

3. Evaluate the effectiveness of the system in accomplishing its intended purposes by determining

   a. The utility of a curriculum information system - Working with local school districts in "real life" situations was to provide PRIMES staff with a set of specific questions that were actually addressed to the system. Careful documentation and assessment of the way in which the system was used to answer inquiries would guide the further development of the system.

   b. Degree of user satisfaction - Several school districts were to be studied to determine present procedures in curriculum decision-making and the ways in which the system affected these procedures. The data was to be used to evaluate this approach to curriculum decision-making and to provide guidance for changes required in a full-scale program.

c. Economic and technical feasibility - Applying information retrieval technology to education requires careful study of costs to determine services that are technically and economically feasible.

METHOD

PRIMES has designed and implemented detailed procedures for system development and system utilization.

SYSTEM DEVELOPMENT

Unit Document

The system document consists of three basic elements - the analysis sheets, the teacher manual page, and the pupil text page (Figure 1). Selected characteristics of each textbook of twenty published elementary mathematics basal series have been analyzed, lesson-by-lesson. The analytical categories are:

1. Content - Each lesson is classified according to the mathematics concepts presented. A master list of more than three hundred content items, classified under seven general mathematics topics, is used in assigning a content code number.

2. Expected pupil behavior - Each lesson is assigned specific objectives. Approximately fifteen hundred objectives, stated in behavioral terms, are contained in the master list used in lesson classification.

3. Type of problem - The problems and examples included in each lesson are classified according to four main types: direct application of lesson, review, extended application, and exploratory activities. The format, computational or problem solving, is also indicated.

4. Vocabulary and symbolism - Whenever a technical term or symbol is first introduced, it is entered on the analysis page and noted on the teacher's page for that lesson.

5. Grade level - All lessons are coded according to the school year and month for which they are intended.

6. Pre-text activity - Suggested preparatory activities described in the teacher manual are identified.

7. Post-text activity - Suggested activities for lesson follow-up are identified on the teacher's page.

FIGURE 2

SAMPLE UNIT DOCUMENT

ANALYSIS — TEACHER PAGE — PUPIL PAGE

643210 **Accession Number**

Content

II. Numeration and Notation

C.1. Reading and/or writing words or numerals for the ten basic symbols (0-9)

I. Number Systems

A.1.e.1. Counting to find cardinal number of set (one-to-one correspondence)

3050

0060

11 **Grade Level**

Problems and Exercises

A1

Vocabulary

Number is a property of sets, N notation

Expected Pupil Behavior

01140 B-N 5

Selects the proper numeral when shown a set written in N notation followed by an equal sign. Numbers 1 to 12.

64321

Counting the number of things in a set

$N\{\ \} = 0$

$N\{\text{goat}\} = 1$

$N\{\text{goat, pig}\} = 2$

$N\{\text{goat, duck, pig}\} = 3$

$N\{\text{goat, duck, pig, goose}\} = 4$

a1

Teaching Page 24

COMMENTS:

The concept of number is introduced as well as the notations for the numbers 0 through 4. Number is introduced as a property of a set and this is made explicit by the N notation. From the concept of set we move to a more abstract consideration of the number of elements in a set. We will be concerned not *with what* things are members of a set but only with *how many* there are. Thus the N notation means "number of things," "how many," or simply "count the members" to the children.

Prior to the introduction of page 24, number may be described as a property of sets. A discussion of properties in general and of number property in particular is recommended. Refer to the General Discussion section immediately preceding for detailed suggestions for developing the notion of number as a property. Introduce the N notation in relation to this discussion.

The Arabic numerals are introduced as an alternative way of describing a number. For example, the number associated with a set consisting of a goat and a pig *is the same as* the number named by the numeral "2."

The central role of the counting operation is obvious as emphasized in the page's title. The child must know or learn the sequence of integers through 9 to complete the work in this section. The recognition of the Arabic symbols is also a component skill. It should be noted that it is not always necessary to require the child to count object by object to determine the cardinal number associated with a set. Particularly with the sets of one, two, and three objects, the recognition of their cardinality may be immediate. It is also true that we want the child to associate the number with the entire set and not with any particular member. However, the operation *of counting is* still basic to the work in Part 4 and the teacher is advised to give enough [illegible] to assure facility.

SUGGESTED PROCEDURES:

1. *Discuss* properties of objects which can be displayed. Such properties as color, shape, texture, etc., are familiar to children (See General Discussion, Part 4). Name several objects which share a common property and ask in what way they are alike. Describe or exhibit three *sets* which have the same number of *members* and let the children determine that they have in common the property of number.

2. *In* relation to the introduction of number as a property of sets, write an example of the N notation. Indicate that the N means the *number* of things in the set.

3. Discuss page 24 by referring first to the illustration. Emphasize that here we are interested in *how many*, not *what* [illegible] Emphasize that the N *refers to number*, not [illegible] to count.

4. Point out that the Arabic *symbols* are ways of *referring* to numbers also. The "4" shows us that, for example, "1" is a way of writing the number of things in the set consisting of a donkey. Similarly, the number of things in the *empty set is the same as* zero.

5. Direct attention [illegible] each set in order has one more member and *this is* what we're referring to when we count "1, 2, 3, 4." Each step in the counting sequence means one more.

6. Give additional practice in counting if necessary

Counting the number of things in a set

$N\{\ \} = 0$

$N\{\text{goat}\} = 1$

$N\{\text{goat, pig}\} = 2$

$N\{\text{goat, chicken, pig}\} = 3$

$N\{\text{goat, duck, pig, goose}\} = 4$

a1

- MATHEMATICS CONTENT
- GRADE LEVEL (YR. & MO.)
- PROBLEM TYPE
- VOCABULARY-SYMBOLISM
- EXPECTED PUPIL BEHAVIOR

PRE-TEXT ACTIVITY

POST-TEXT ACTIVITY

Analysis

The analysis procedures for producing the system document are based on standards developed by specialists in mathematics education, educational psychology, curriculum, and information sciences and technology. The actual analysis was done by educators experienced in doing the type of analysis required by the system. The analysis responsibility was divided among four groups of people: the content analysts, the behavior analysts, the problem-type analysts, and the features editor. Work began at Harrisburg where the project staff identified the programs to be analyzed, assigned the analytical work, and sent copies of the teacher manuals for each program to the respective analyst.

The content analysts were professors of mathematics at colleges or universities in the Commonwealth. These analysts were trained and their work was supervised by the senior editor of the project. The analytical work consisted of identifying the mathematics content of each lesson and recording the appropriate codes on the book itself. The codes were selected from the Content Authority List which was the analytical tool for this classification. The list of about three hundred mathematics concepts and skills was developed by a committee of nationally recognized mathematics educators.

Similarly, the behavior analysts studied every lesson of each basal textbook and assigned one or more behaviors that the pupil is expected to demonstrate as a result of the indicated instructional activities. The master list of behaviors, Behavior Authority List, was based on the mathematics curriculum research work done at the Learning Research and Development Center, University of Pittsburgh. The list, of approximately fifteen hundred pupil objectives, was applied to each lesson by seven classroom teachers trained and supervised by the authors of the list. The analysts recorded the appropriate behavior codes on the book itself and sent the books to the supervisor for review.

The problem-type analysts assigned problem-type codes directly on a copy of the teacher's manual. He also indicated pre- and post-text instructional activities and identified technical vocabulary and symbolism by underlining the words and symbols on the teacher manuals. A vocabulary-symbolism alphabetized summary index was kept for each basal textbook series and was included at the end of the document file for that textbook. This analytical work was done by two classroom teachers who were trained and supervised by the project staff.

The features editor reviewed each textbook to identify those salient features which could be documented and prepared a written draft description of the features of each program. The features of the pupil textbook and teacher manual content and organization and the scope, sequence, and development of mathematics content were described following an outline developed by the editor (Figure 2). This draft was typed and sent to the publisher for review, after which it was re-edited and a final draft prepared. The features section was also included at the end of the document file for each textbook.

Analytical Tools

The Content Authority List (Figure 3) is a list of mathematics concepts and skills that may be taught from kindergarten through grade six. The list is arranged in a hierarchical order with each topic identified by a unique number.

The second authority tool is the Behavior Authority List (Figure 4) that is logically related to the mathematical content list. There are eleven mathematics topics in five major levels of skill-activity difficulty, A-E. The specific behavioral statements are classified under one of these eleven topics.

The problem types were defined by the same mathematics educators who developed the Content Authority List. The four basic categories are: (1) direct application of the lesson, (2) review, (3) extension of the lesson application or generalization, and (4) exploratory, preceding formal teaching. The first category was coded A; the second, B; the third, C, and the last, D. Each problem was further described for its format with computation coded 1 and problem-solving 2 (Figure 5).

A master alphabetized list of technical vocabulary-symbolism was provided for the analysts. This list was greatly expanded because nonstandard vocabulary and symbolism may be indicated as integral to the developmental philosophy of a particular basal program. This was determined by the analysts after thoroughly studying the overview of the program and the manual discussion for each lesson. Numerical codes were not used for the vocabulary-symbolism. An index was compiled for each textbook (Figure 6).

FIGURE 2

OUTLINE FOR FEATURES

Features Checklist: Development of Content
Points to be Noted

1. Counting

2. Cardinal Numbers - meaning and writing of; sequence of development

3. Ordinal Numbers - meaning and writing of; sequence of development

4. Place Value

5. Addition - meaning - where and how developed
   Subtraction
   Multiplication - computation - where and how developed
   Division

6. Measurement - length, time, liquids, money, etc.

7. Fractions - meaning - where and how developed

8. Word Problems - where and how developed - use of number sentences

9. Emphasis on Concepts and Skills

10. Provision for Individual Differences, including Enrichment

11. Reviews

12. Tests

13. Some "Modern" Topics and Procedures

    a. Use of discovery and inquiry
    b. Equalities and inequalities
    c. Development of generalizations
    d. Geometry
    e. Number line
    f. Numerals as names for a number
    g. Odd and even numbers
    h. Properties of operations
    i. Properties of one and zero
    j. Regions - interior and exterior
    k. Sets
    l. Use of precise vocabulary

FIGURE 3
SAMPLE PAGE - CONTENT AUTHORITY LIST

Mathematical Content Authority List: K-6 October 1967

0002. . . Topic I: Number Systems

0004. . . . . A. Whole numbers

0006. . . . . 1. Basic concepts

0010. . . . . a. Definition: set of whole numbers

0020. . . . . b. Developing cardinal number zero

0030. . . . . c. Developing cardinal numbers one through ten

0035. . . . . d. Developing cardinal numbers beyond ten

0040. . . . . e. Developing ordinal number sense

0050. . . . . f. Associating idea of number with number line (one-to-one correspondence)

0060. . . . . g. Counting to find cardinal number of set (one-to-one correspondence)

0070. . . . . h. Ordinal counting

0075. . . . . i. Sequence of numbers increasing by one

0080. . . . . j. Skip counting

0090. . . . . k. Other counting: backward, rote, etc.

0100. . . . . l. Ordering numbers and objects as greater than; less than; equal to

0102. . . . . 2. Operations

0104. . . . . a. Addition

0106. . . . . 1) Properties

0110. . . . . a) Definition: addition, a binary operation

0120. . . . . b) Addition developed from union of disjoint sets or joining action

FIGURE 4

SAMPLE PAGE - BEHAVIOR AUTHORITY LIST

038992 H. Level D. Geometry

039000 1. Locates or identifies parts of a circle: center, diameter, radius, chord, semicircle.

039040 3. Identifies a parallelogram, a rhombus, a convex irregular polygon, a concave irregular polygon.

039041 3. Selects from among a number of figures: a parallelogram, a rhombus, a convex irregular polygon, a concave irregular polygon.

039060 4. Finds perimeter for parallelograms, rhombi, regular polygons or irregular polygons by measuring.

039080 5. Measures angles using a protractor.

039081 5. Draws angles with a protractor.

039100 6. Identifies the value of "pi".

039101 6. Demonstrates how value of pi (π, 3 1/7) is established.

039120 7. Finds the circumference or area of a circle using the formulas $C = \pi d = 2\pi R$ or $A = \pi R^2$.

039140 8. Uses formulas to find the perimeter of a square, rectangle, triangle, parallelogram, or other geometric figure.

039161 9. Constructs a line segment congruent to a given line segment.

039181 10. Constructs an angle congruent to a given angle.

039182 10. Constructs an angle which is larger or smaller than a given angle.

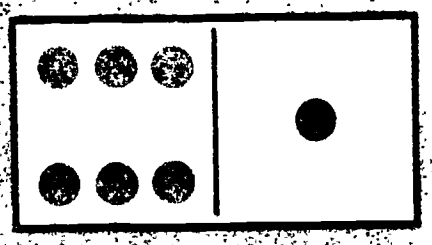
039200 11. Bisects a given angle using a compass and straightedge.

FIGURE 5

SAMPLE PAGE - PROBLEM TYPE

2 0 1 1 4

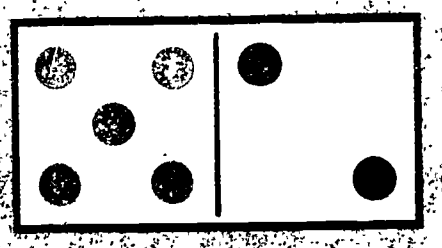
1.



6 + 1 = ____ 7 − 1 = ____

1 + 6 = ____ 7 − 6 = ____

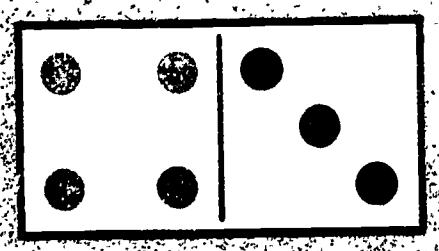
2.



5 + 2 = ____ 7 − 2 = ____

2 + 5 = ____ 7 − 5 = ____

3.



4 + 3 = ____ 7 − 3 = ____

3 + 4 = ____ 7 − 4 = ____

4.

6	2	5	2
+1	+4	+2	+1

5.

1	2	3	2
+6	+3	+4	+5

6.

4	1	2	7
+3	+4	+2	+0

7.

7	6	7	7
−2	−4	−6	−4

8.

7	6	7	5
−7	−3	−5	−3

9.

6	7	7	7
−5	−1	−3	−0

a.

FIGURE 6

SAMPLE PAGE - VOCABULARY INDEX

04575

American Book Company
Book One Meeting Mathematics 1965
Deans . Kane . Oesterle

-A-

1.	add	TG5	27.	fewer than	TG4
2.	addends	TG57	28.	fewest	TG6
3.	addition	P108	29.	fifth	TG3
4.	after	TG4	30.	fifty	P132
5.	altogether	TG2	31.	first	TG3; P2
	-B-		32.	five	P7
6.	before	TG4	33.	foot	TG52
7.	between	TG4	34.	forty	TG66
8.	bottom	TG2	35.	four	P7
	-C-		36.	fourteen	P174
9.	cent	TG59; P112	37.	fourth	TG3
10.	cent sign	TG59	38.	fourths	TG71
11.	clock	TG72; P141		-G-	
12.	clockwise	TG72; P141			
13.	count	TG63; P119		-H-	
14.	cup	TG52	39.	half dozen	TG87
	-D-		40.	half hour	TG85
15.	day	TG36	41.	half past	P178
16.	different (sets)	TG3	42.	highest	TG48; P85
17.	dime	TG59; P112	43.	hour	TG72
18.	doubles	TG43; P72	44.	how many	TG2; P1

Grade level was determined by the number or letter assigned by the publisher. The month was determined by dividing the number of pupil pages by the number of school months (9). Two-digit codes were used, the first indicating grade and the second indicating month. For example: 21 is Grade 2, September; 65 is Grade 6, January; 07 is Kindergarten, March.

Pre-text activities were noted on the teacher manuals with a single check and a single squiggle. Similarly, the post-text activities were marked with a double check and squiggle (Figure 7).

Production

Materials were prepared for microfilming at Harrisburg. The analytical data, content, behavior, problem type, and vocabulary-symbolism codes were conformed on a summary form, Lesson Summary Sheet (Figure 8). The content and behavior codes were verified for validity and reasonableness. At this time the document number, accession number, and the grade level were assigned.

From the Lesson Summary Sheet the numerical codes were transcribed to Lesson Keypunch Forms (Figure 9). The forms were sent to Bureau of Educational Data Processing where they were keypunched, interpreted and listed for computer input. The keypunched cards were then used to generate the print analysis pages and the master indexes.

The teacher manuals and pupil textbooks were cut, collated, and stamped with an accession number and problem type. The next activity was the transcription of pre- and post-text activities notations from the analyst copy to a clean camera-ready copy of both the pupil and teacher books. The analysis pages were proofread and sent back for correction if needed. Symbols that were not printed by the computer were indicated by an asterisk and handwritten.

The computer-printed analysis page, the noted manual pages, and the pupil textbook pages were then collated and prepared for microfilming. Lessons that required multiple frames, i.e., trailer cards, were identified during this copy preparation work.

The features and the vocabulary summary were typed. The vocabulary summary includes the page number at which the vocabulary is first introduced. The typed copy of the features was sent to the publisher for editorial review.

FIGURE 7

SAMPLE PAGE - PRE-/POST-TEXT ACTIVITIES

Addition and subtraction: sums of 7

20414

PURPOSE

To relate subtraction facts to the corresponding addition facts.

PRE-BOOK TEACHING

1. Make and use flap cards as described on page 70 with the following dot patterns on them: 6 and 1; 5 and 2; 4 and 3; 7 and 0.

2. Ask the children to tell you (without the aid of pictures) what other number sentences belong in the family of each of these sentences. Record each family on the chalkboard.

$6 + 1 = 7$ $\quad 4 + 3 = 7$
$5 + 2 = 7$ $\quad 7 + 0 = 7$

PROCEDURE

Discussion

Do the page orally, first calling attention to the number sentence families in Ex. 1 to 3. Have children state the whole number sentence, not just the answer, in all exercises.

You may wish to have several children demonstrate some of the sentences on the number line.

Written Work

Pupils may now proceed independently to write their responses to the exercises on this page.

SUPPLEMENTARY

1. Copy the following on the chalkboard and have the children tell what signs belong on the colored blocks. Note the last two sentences, in one of which a + sign may be used, and in the other a − sign.

7	▒	4	=	3
2	▒	4	=	6
7	▒	7	=	0
7	▒	0	=	7
7	▒	0	=	7

2. Children enjoy playing the game described below.

Game

Stranger in the Family

Place the following rows of addition and subtraction facts on the board. Point to the first row and say: **In this row of number facts there is one fact that does not belong. There is a stranger in the family. What is it?** After the answer $7 - 6 = 1$ has been given, have the pupils find the "stranger" in each of the other rows.

(a)	3 + 4 = 7	4 + 3 = 7	7 − 4 = 3	7 − 6 = 1	7 − 3 = 4
(b)	7 − 6 = 1	1 + 6 = 7	7 − 1 = 6	6 − 1 = 5	6 + 1 = 7
(c)	4 + 2 = 6	2 + 2 = 4	6 − 4 = 2	2 + 4 = 6	6 − 2 = 4
(d)	5 + 1 = 6	5 + 2 = 7	2 + 5 = 7	7 − 5 = 2	7 − 2 = 5

For Faster Learners

Complete these number sentences:

$(6 - 3) + 4 = \square$
$(7 - 2) + 1 = \square$
$5 + (7 - 7) = \square$
$\square + (6 - 2) = 7$
$(7 - 3) + \square = 6$

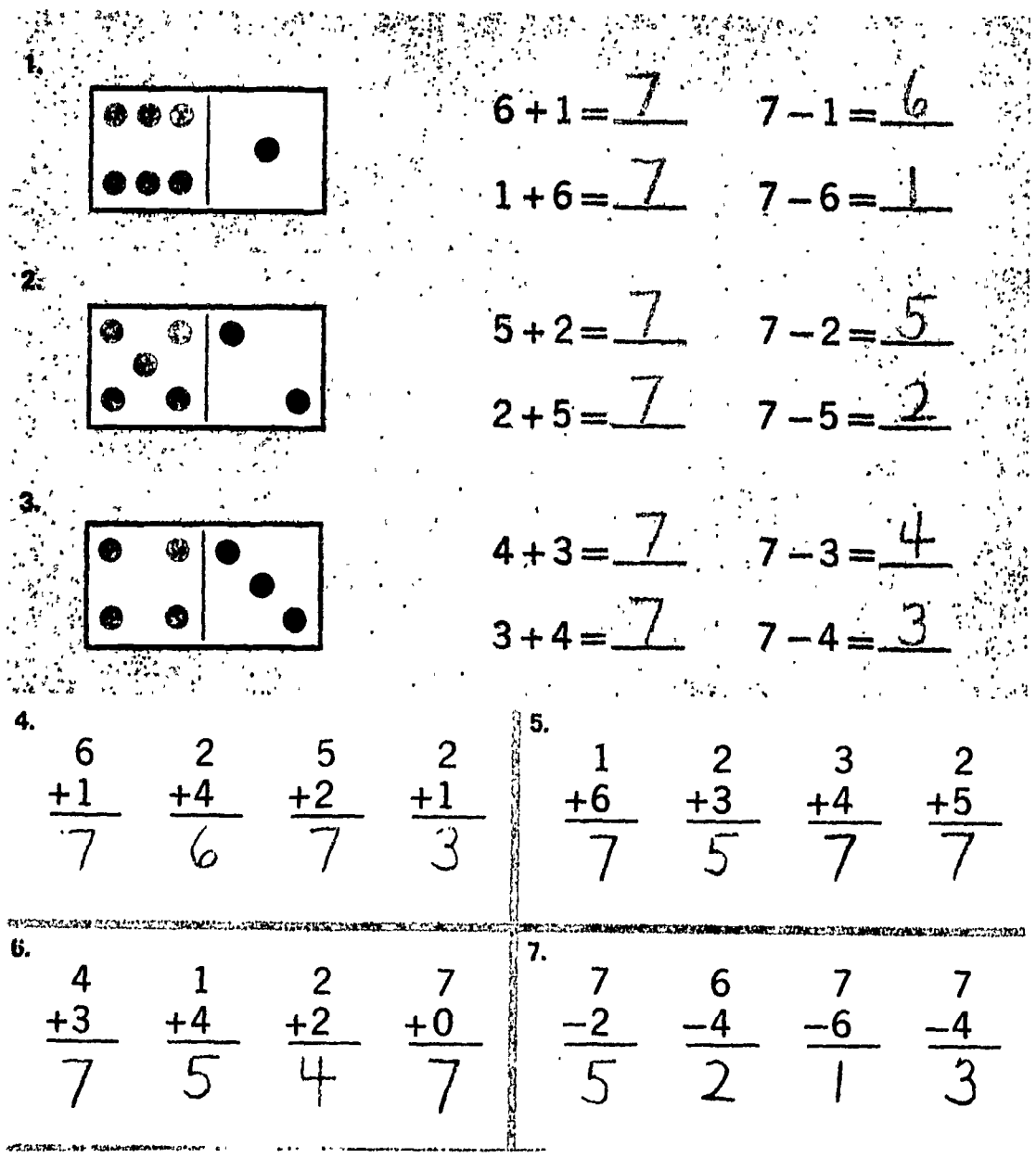


FIGURE 8

SAMPLE PAGE - LESSON SUMMARY SHEET

COMPANY: HARCOURT, BRACE, WORLD BOOK NO. 3

ACCESSION # AND PAGE	GRADE LEVEL	PROB. TYPE	CONTENT	BEHAVIOR	VOCABULARY AND SYMBOLISM	PAGE
#21003 124	3-4	A-2	VIII C7 (9080)	C-MO 27 a, c, d (14520)	TOTAL VALUE	124
#21004 125	3-4	A-1	V E (6050)	C-T6 (20100)	DAY YEAR WEEK	125 125 125
#21005 126	3-4	A-1	VII J (8150) II C6 (3100)	C-A7 (08120)		
#21006 127	3-4	A-1	VII J (8150) I A2a2a2b (0210)	C-A7 (08120)		
#21007 128	3-4	A-1	VII J (8150) I A2b2b1 (0330)	C-S12 (09220)		
#21008 129	3-4	A-1	VII J (8150)			

FIGURE 9

SAMPLE PAGE - LESSON KEYPUNCH FORM

IBM GENERAL PURPOSE CARD PUNCHING FORM

PUNCHING INSTRUCTIONS

JOB HARCOURT, BRACE, WORLD BK. 3

BY QCC/ms DATE 7/26/67

WRITTEN AS:

PUNCH AS:

Acc. No. NOTES: FIELD IDENTIFICATION	Level	Problem Type	Content Code			Behavior Code			Vocabulary Symbolism
	1-10		11-20	21-30		31-40	41-50	51-60	61-70
1	209950	34 A1	0190	0310		02020	08280		
2	209960	34 A1	0210	0330		08064	09187	06360	
3	209970	34 B1	9010	0190	0310	02000	09040		
4	209980	34 B1 B2	9010						
5	209990	34 A2 A1	0200	0310	0330	08220			
6	210000	34 A2	0200	0310		08540	09400		
7	210010	34 A2	0210	0330		14080	14081		
8	210020	34 A1 A2	0210	0330		08220			
9	210030	34 A2	9080			04520			TOTAL VALUE
10	210040	34 A1	6050			20100			DAY, YEAR, WEEK
11	210050	34 A1	8150			08120			
12	210060	34 A1	8150	0210		08120			
13	210070	34 A1	8150	0330		09220			

The camera-ready copy was sent to a commercial company for microfilming. The original film is on 35-mm rolls which are stored. Duplicate sets of the film are produced on aperture cards and rolls which are stored at the Department (Figures 10, 11).

A system for utilizing the computer to prepare the analysis pages, authority lists, and indexes resulted in considerable reduction of clerical effort and error (Figures 12, 13). The primary inputs to the computer system were the numerical codes recorded on a prescribed form, Lesson Keypunch Form. The other input was changes made to the behavior and content lists. The output from the computer system included the camera-ready copy of the lesson analysis sheets, a complete set of punched cards representing the index card file which is searchable on electronic sorting equipment, printed indexes for manual searching arranged by content and behavior, and updated behavior and content lists.

The authority lists have been coverted to machine-readable form and were maintained on a magnetic tape file which can be printed on demand. Changes can be readily made on these lists.

Cumulative book-form indexes were generated by computer to aid searching. The printed indexes represent a combination of machine-readable authority files and index files. The index first lists the numerical code and the category heading in English language which is then followed by a list of the code numbers and accession numbers which fall under that category. Use of the computer has made periodic updating of the indexes possible (Figures 14, 15).

FIGURE 10
ANALYSIS AND COPY PREPARATION - WORK FLOW

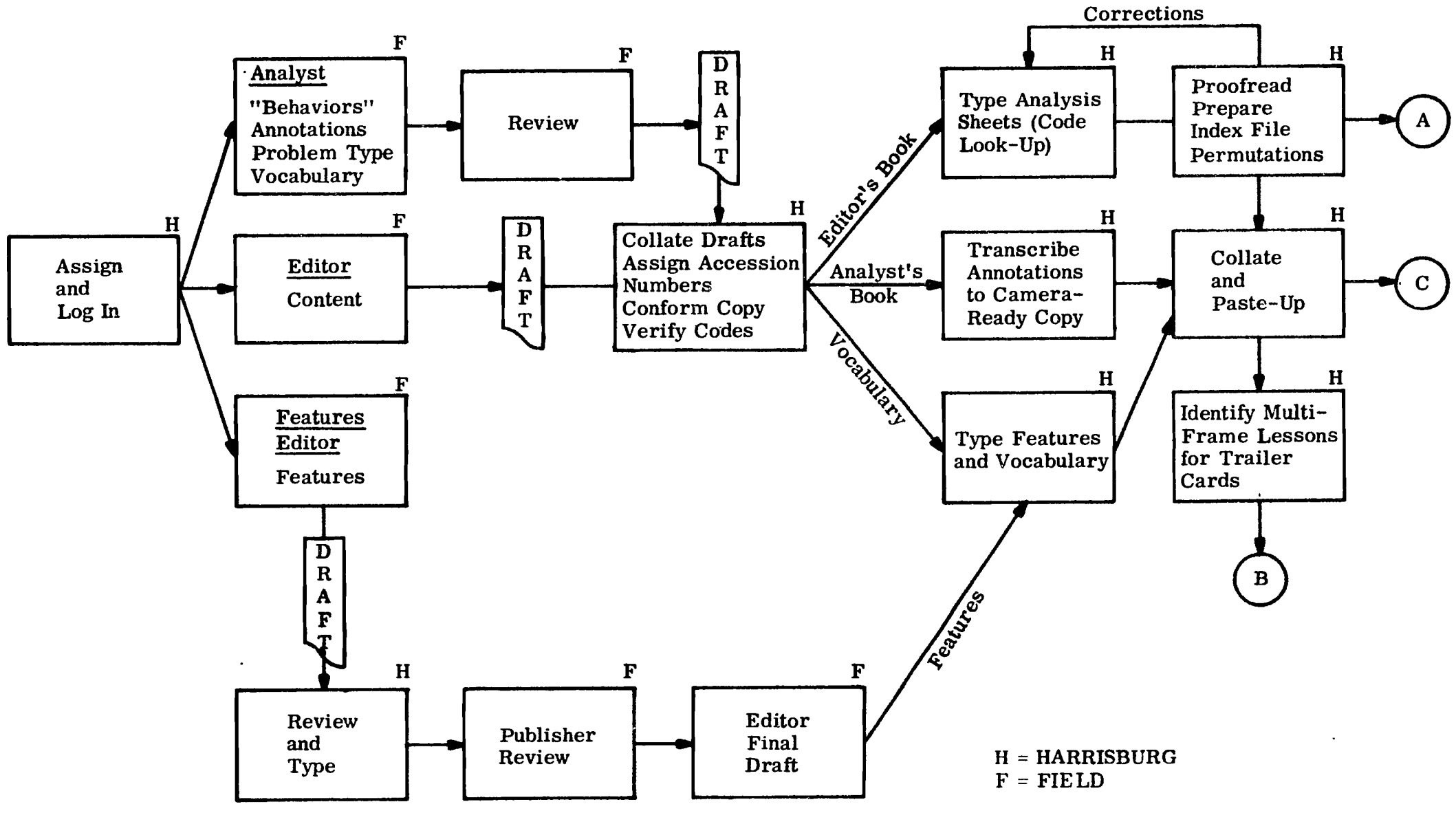
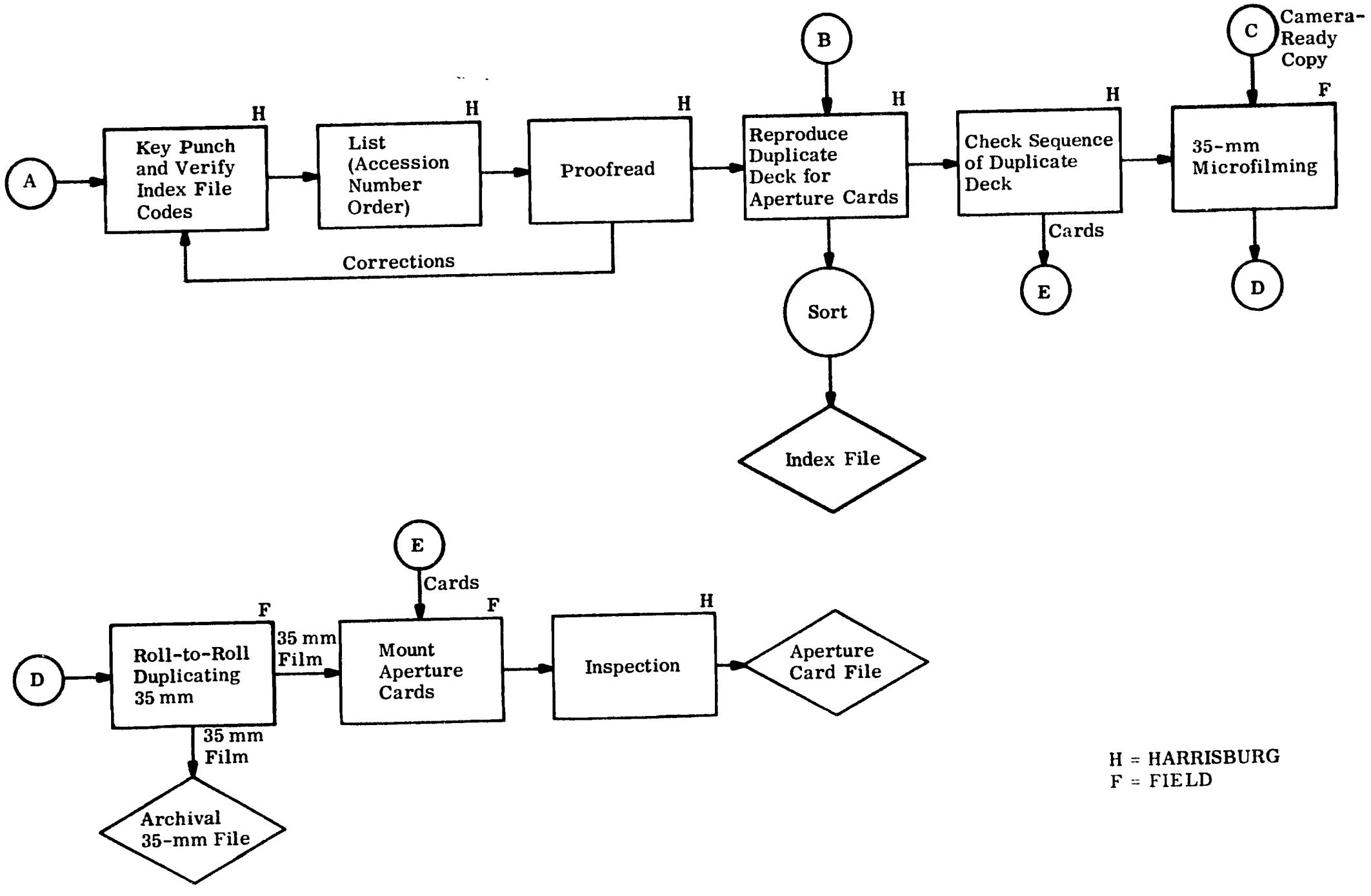


FIGURE 11

MICROFILMING AND FILE MAINTENANCE - WORK FLOW



H = HARRISBURG
F = FIELD

FIGURE 12

COMPUTER-AIDED WORK FLOW

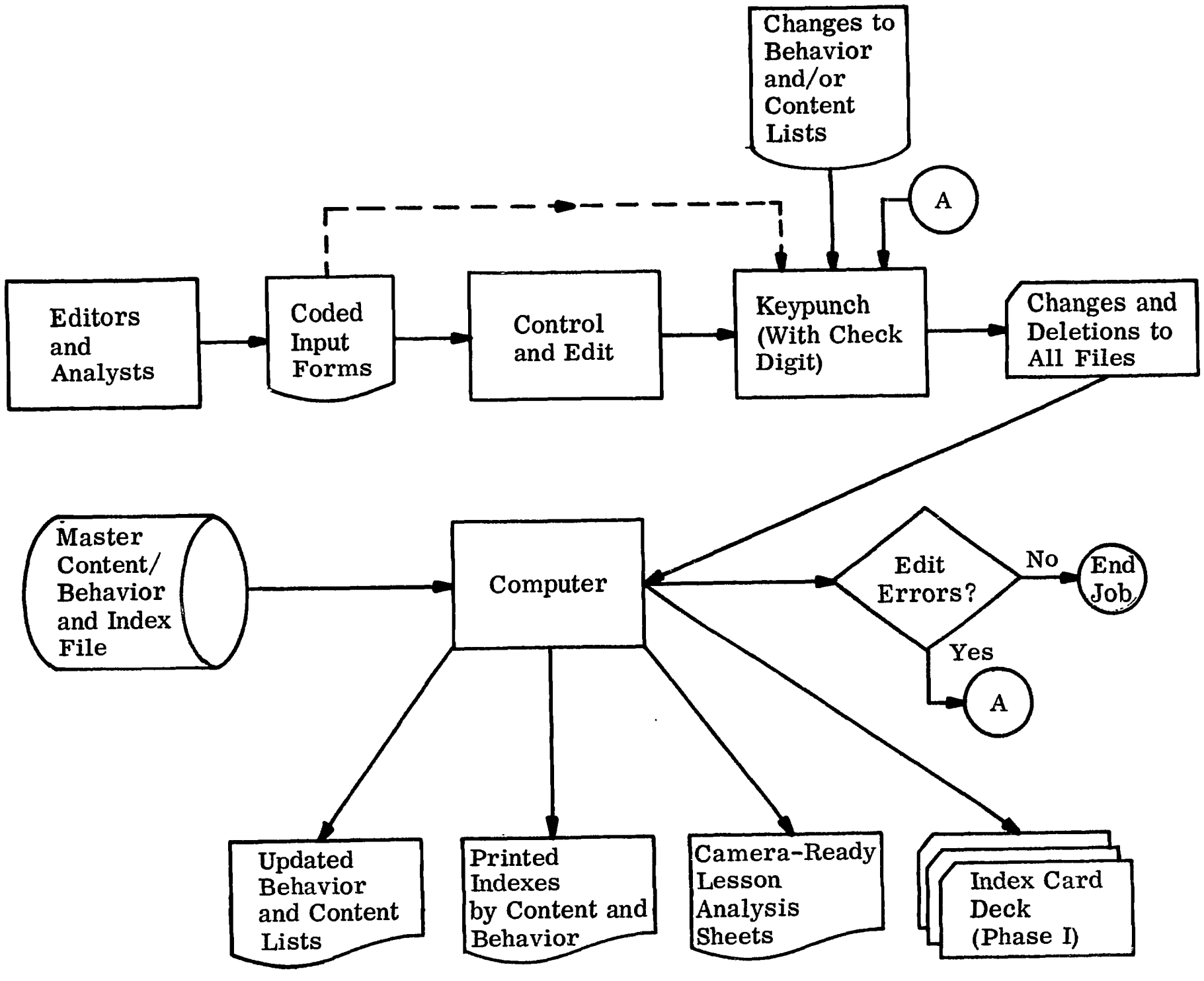


FIGURE 13

OVERALL COMPUTER INPUT - WORK FLOW

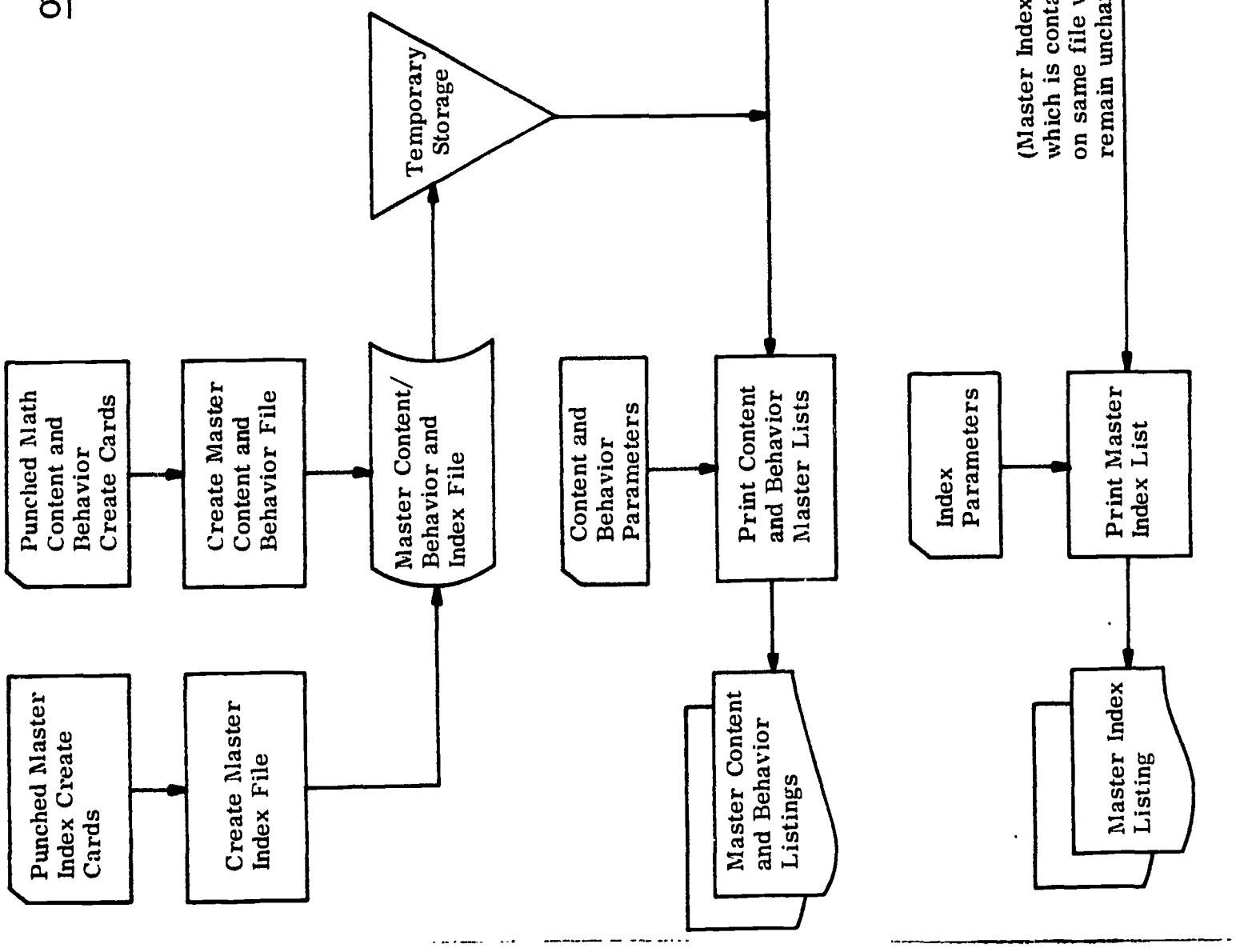


FIGURE 14

SAMPLE PAGE - CONTENT INDEX

CONT	ACCESS	BHVR	LEV	PE
07000	1. ODD-EVEN			
	007400	06120	27	A1
	007420	05080	27	A1
		05220	27	B1
	007430	05160	27	A1
	007440	06120	27	A1
	046100	01980	21	A1
	164420	06120	18	A1
	166650	06120	14	A1
	203770	06040	15	A1
	209080	06120	31	A1
		06240	31	A1
	363830	06120	14	A1
	366270	06120	12	A1
	366990	06120	15	A1
	446350	06120	23	A1
	484110	02300	17	A1
	484120	06120	17	A1
	486430	06120	22	A1
	486610	06540	24	A1
	486620	06120	24	A1
	486630	06120	24	A1
	604490	06120	18	A1
	647750	06120	28	A1
	686140	01960	22	A1
07090	1. ARITHMETIC PROGRESSIONS			
	284250	06020	18	A1
	284280	06240	19	A1
	284290	06240	19	A1
	284310	06240	19	A1
	284320	06240	19	A1
	284330	06020	19	A1
	404590	06240	19	A1
	407360	06240	28	A1
	407370	06240	28	A1
07110	3. TRIANGULAR NUMBERS			
	123410	06160	14	A1
07140	6. GRID GAMES			
	046470	02040	23	A1
	047430	04800	28	B1
	206980	04800	26	A1
07160	C. SPECIAL PATTERNS (INCLUDING SHORT CUTS)			
	123080	00390	11	A1
	123650	06360	16	A1
	123730	06360	17	A1
	123810	08240	17	A1
	123880	06360	18	A1
	123890	06360	18	A1
	123910	06240	18	A1

CONT	ACCESS	BHVR	LEV	PE

FIGURE 15

SAMPLE PAGE - BEHAVIOR INDEX

BHVR	LEV	ACCESS	PE	CONT
01800	6. PROVIDES OR COMPLETES AN ADDITION NUMBER SENTENCE USING THE + AND = SIGNS FOR PICTURES COMPOSED OF GROUPS OF OBJECTS OR SETS WRITTEN IN N NOTATION. RESPONDS BY WRITING THE NUMERALS. SUMS TO 20.			
	23	406450	A1	00120
		566670	A1	00190
		566680	A1	00190
		566700	A1	00190
	24	206650	A1	00150
				00310
		446370	A1	00150
	25	446500	A1	00190
		446600	A1	00150
		606800	A2	00150
				00270
	26	446660	A1	00150
	28	446880	A2	00310
01820	7. CONSTRUCTS OR COMPLETES THE APPROPRIATE SETS, FOR SUMS TO TWELVE, WHEN GIVEN A NUMBER SENTENCE CONTAINING A + SIGN AND = SIGN.			
	09	441310	A1	00030
				03050
	11	603210	A1	00120
		603220	A2	00120
		603230	A1	00120
	12	603310	A1	00120
		603320	A1	00120
				00190
	13	043450	A1	00120
				00250
	14	403690	A1	00190
				00310
		403730	A1	00190
				00310
	15	003880	A1	00190
		403810	A1	00190
				00310
	16	004040	A1	00120
		004130	A1	00190
		283900	A1	00310
	17	004220	A1	00120
		404210	A1	00190
	18	004400	A1	00190
	21	606170	A1	00120
01840	SYM.8. SUPPLIES THE CORRECT SIGN, = OR $Q FOR ADDITION STATEMENTS USING NUMERALS AND + SIGN. ONE-STEP EQUATIONS AND SUMS TO 12.			
	13	283460	B1	09000

BHVR	LEV	ACCESS	PE	CONT

SYSTEM UTILIZATION

Providing local school districts with the services of PRIMES presented a major problem - the products were too complex for local school district personnel to use effectively without prior training in curriculum development work and system utilization. PRIMES developed a plan to resolve this problem. Two basic issues had to be considered: (1) Should servicing school district be centralized or decentralized? (2) What procedures for utilization of the system could most effectively satisfy the needs of the districts?

A totally centralized operation would provide for all of the functions at one location. Arguing against this type of organization are the problems imposed by peak loads, professional staffing requirements, and the amount of time required for travel. An integral aspect of the system is a dialog between the user and the reference specialist to ensure thorough communication of the intent of the search question. Ideally, this takes place best when the user and the reference specialist are face-to-face. If this is not possible, telephone communication is a second choice. A second system requirement which favors decentralized operation is the need for evaluating each document retrieved by the index search function for relevancy to the question. While this is performed at a first level by the reference specialist, it must ultimately be performed by the user. Hence, if the information center is sufficiently close to the user, it would be possible for the user to utilize the system in person.

For these reasons it was decided that service to users be provided by regional centers located in areas convenient to user groups. The number and location of these centers will be determined by considerations of available organizational facilities, financial support, and trained staff.

While it is more efficient and effective to provide the reference services on a decentralized basis, conversely it is more efficient to prepare the input to the system on a centralized basis. The cost of analysis and input to an information retrieval file is substantial. Therefore, it should only be performed once which does not imply that the input must all be physically prepared in the central location. The intellectual functions should be performed by those best qualified wherever they are located. However, the co-ordination as well as the physical input processes should be done centrally, as well as the duplication and updating of all files for use in the regional centers.

A Plan for Regional Centers

A design for establishing regional centers was completed. It includes:

1. A master plan for the design, development, and implementation of a model regional center.

2. The functions to be performed, the files to be maintained, the inputs required, the products and services to be produced, the output formats, the interface with the central facility, and specifications for any special programs required.

3. The types and number of personnel required to staff the regional center.

4. The manner in which questions are received, the records that are to be maintained, the services that are to be provided, the procedures for file maintenance, the development or identification of special reference tools, and the mode of and procedures for communicating with the user.

5. Procedures for training the staff complement and necessary training tools.

6. Orientation programs for users to acquaint them with the availability of service and also to acquaint the users with how they can best utilize the system.

7. On-site checkout of system visits to insure that the system is operating in accordance with the system design specifications. Where problems are identified, recommended solutions are developed.

8. Procedures for measuring and evaluating the performance of the system at regional centers.

9. A procedures manual to provide a precise, systematic plan for users to construct curriculum guides and select appropriate instructional materials using the system. The manual describes the curriculum committee composition, its fifteen discrete tasks to accomplish the two objectives, the time schedules for implementing the tasks, and the final products that should result from this curriculum effort.

Processing Inquiries

The first activity in establishing the service capabilities of a regional center is an orientation by the curriculum adviser for the users explaining how the system can assist them in curriculum development. This curriculum consultation would take place over a period of several weeks or months. The users of the system would be invited to submit questions which could be answered by the information system. The questions would be addressed to the system by telephone, a letter, or a personal visit. Upon receipt of the question, a staff member would record it on a pre-printed form, log it in, and stamp the date of receipt as a basis for getting statistics on the total time it takes to process the question. The question would then be assigned to a reference specialist.

The reference specialist would formulate the search query in the restricted language of the system. This means that the various concepts included in the question must be coded according to the behavior and content lists, problem types, grade levels, etc. He may have to contact the user to clarify the exact intent of the question to insure that the system responds with an answer to the user's question and not to a hypothetical question which the reference specialist may otherwise assume to be the problem.

The reference specialist will scan an index to completed searches to determine whether or not there has already been a similar search. If one is found, the reference specialist will update or modify the search as required. The search can be performed using the printed indexes. The searcher will scan for either a behavior code or a content code and manually examine the entries under that code for the presence or absence of other codes in the question according to the search logic. The output of the search process will be a list of accession numbers of the lessons which satisfy the criteria of the search question. The aperture cards from the document file will be pulled by accession number.

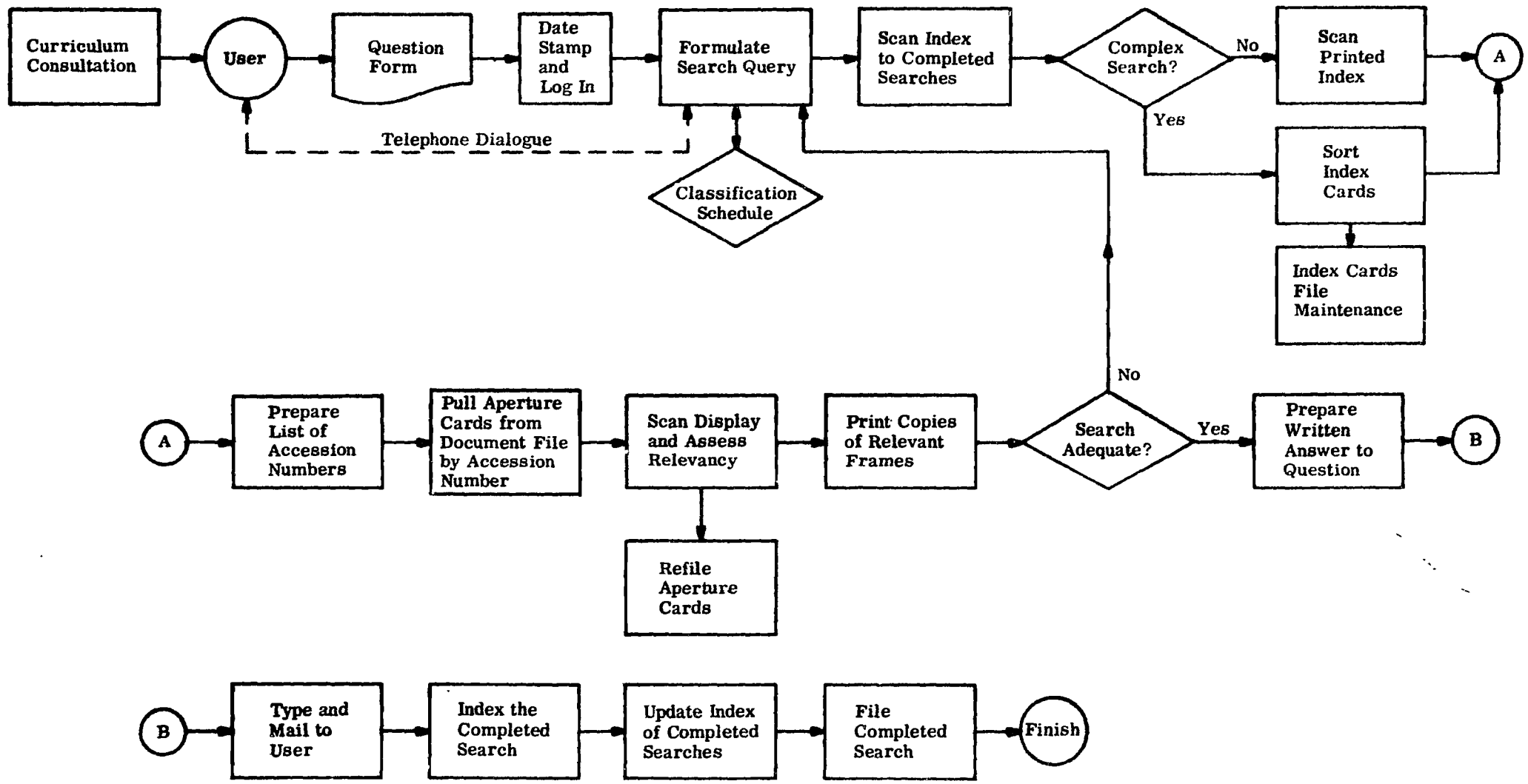
The aperture card is then inserted into a microfilm reader and reviewed to access relevancy of the particular item or document. If the search is satisfactory, the answer to the question is prepared and sent to the user. Answers may take one of several forms - a list of page numbers referring to the original textbook, a narrative, microfilm duplicates, or a copy of the unit document printed out on the reader-printer.

After completion of the search, the question is indexed so that the results may be used to satisfy future search questions without the intervening steps of scanning the index and analyzing the documents themselves. The completed search index file is then updated and the completed search, including a copy of the answer sent to the user, is filed in the completed search document file.

Special studies of curriculum matters of general interest are handled in much the same way and are indexed as completed searches. The primary difference, however, is that the results to these questions are mass-produced by some form of duplication. Rather than filing a single copy of the answer, as in the case of an individual search question, a supply of copies is stored. Similarly, the special studies may be prepared in advance for questions which may be of interest to a large number of users (Figure 16).

FIGURE 16

REFERENCE SERVICE - WORK FLOW



RESULTS

The results discussed in this section concern the activities of PRIMES from January 1966 through June 30, 1967. Developmental work and servicing local school districts are continuing activities. These experiences lead inevitably to products modifications and procedural changes which will be described in future reports.

It should also be noted that this section will describe the products, services, and application of PRIMES; it contains little empirical data to support the contention that PRIMES is indeed a more effective system for curriculum development work than traditional methods.

PRODUCTS

PRIMES developed several tools which can assist local school districts in curriculum development activities and selection of appropriate instructional materials. These tools are:

Content Authority List. This list consists of approximately 300 mathematics concepts and skills that may be taught from kindergarten through grade six. It was developed by a committee of nationally recognized mathematics educators. The items are arranged in hierarchical order with a unique number assigned to each of the items. Generic searching is possible by scanning the list which is organized in an English outline format. Additional items to the list are assigned numerical codes using the fourth digit, e.g., an insert between 0030 and 0040 is accomplished by using the number 0035 (Figure 3 - METHOD).

Behavior Authority List. This list consists of approximately 1500 objectives for elementary school mathematics stated in behavioral terms. The basis for the list was the curriculum that was developed for the Individually Prescribed Instruction (I.P.I.) Project at the Learning Research and Development Center, University of Pittsburgh. There are eleven mathematics topics in five major levels of skill-activity difficulty designated by the letters A through E. The entries in this list are more numerous than those in the Content Authority List. The items are not organized in as highly a structured order as those in the Content List. A six-digit code is assigned to each

behavior. Provision has also been made for adding new items to the list.

Indexes. There are two types of master indexes in the system. In the Master Content Index the content items are used as a reference. These are listed by number and in English language. All the accession numbers to which each item in the Content Authority List has been assigned are listed in sequential order in the first column. Numerical codes in parallel columns indicate the behavioral objectives, grade level, and problem types for each accession number. The Master Behavior Index is similarly arranged with the analytical information indicated in this order - grade level, accession number, problem type, and content. These two indexes are the tools used in identifying alternative source materials for teaching specific concepts or in comparing programs (Figures 14, 15 - METHOD).

Vocabulary and Symbolism Lists. The system has compiled a draft of a master alphabetized list of technical vocabulary-symbolism which is continually being updated as new items are noted in the course of analysis. In addition, a vocabulary-symbolism summary index has been compiled for each basal textbook series and is part of the document file for that textbook (Figure 6 - METHOD).

Features. In addition to the lesson-by-lesson analysis the system includes a description of the significant features of each textbook. The features are presented in an objective style and are documented with a page reference. An outline developed by the editor has been followed in describing such characteristics as the organization, scope, sequence, and the development of the mathematics content. The final version incorporates suggestions that were made by the publishers and accepted by the editor. The features are filed with the document file (Figure 17).

Microfilm File. The document file consists of aperture microfilm cards and roll microfilm. When complete, the microfilm aperture card file will exceed 25,000 cards. Each card has an accession number identification and the grade level at which the lesson is taught. The unit document has been described in the METHODS section (Figure 1).

Original published textbooks. The system has all the original teacher manuals and pupil books that have been analyzed and filed in microform.

FIGURE 17

SAMPLE EXCERPTS - FEATURES

General Organization

The Pupil's Text

The Pupil's Text contains 96 large (10 x 14 inches) work pages. The first 53 pages are printed in bright orange, blue, gold, and black. Color is an integral part of the development of the pre-number ideas. On these pages pupils are required to draw lines to show that colored triangular, square, and circular regions belong in certain colored shapes. In the last 43 pages additional color is used to order sets and introduce cardinal numbers one through nine. On these pages pupils are required to:

1. draw lines to show the matching of sets (pp. 55,59,69) or the path of a frog (pp. 73,74).
2. draw forms to make equivalent sets (p. 63).
3. mark an X on the proper set (pp. 65,87).
4. draw a ring around pictured sets (p. 67) or numerals (p. 75).
5. recognize the size of a group and the numeral for its number (p. 83).

The content is developed through games for which children are encouraged to make the rules (T-v) and in which they become accustomed to handling progressively more difficult situations.

Before the pupil uses his text he must know the names of the colors blue, gold, orange, and black and recognize them. He must also know the forms: circle, square, and triangle. The authors believe that a pupil can then proceed at his own rate throughout the text (T-1, 44).

Points to Note

4. The suggested matching games, construction games, finding games (T-xv,xvi), placing games, and classification games (T-97).
5. The emphasis on independent work by the pupils (T-31,40), and on pupil explanation of why each mark was drawn (T-2,4,40). The teacher is directed to check the pupil's work carefully (T-27,39,73).
6. The intuitive development of interior regions (T-48 continued).
7. The intuitive development of set concepts (T-6,48 continued).
8. Provision for additional activities of a more challenging nature though related to the page activity (T-28,63).

SERVICES AT REGIONAL CENTERS

PRIMES has been instrumental in establishing two regional centers to offer its services to local school districts. The first center established was the Westmoreland Regional Instructional Materials Center at Greensburg, Pennsylvania. The center is funded under an ESEA Title III grant and began operations in January 1967. The second center was established in July 1967 at State College, Pennsylvania. Together these regions serve a seven-county area with a total of fifty-one school districts.

Types of services. Three levels of consultative curriculum services are offered to the school districts in the regional center's service area. The types of service are tailor-made to the needs of the local school districts. These services are:

In-depth - this service refers to a comprehensive study of the school's current elementary mathematics curriculum, constructing a new curriculum guide, and selecting appropriate instructional materials to implement this guide. The center commits its staff and resources to work with these school districts over an extended period of time. It is expected that the cooperating school districts will be given the necessary time and facilities to work on the project. The center staff works with the school district on a regularly scheduled basis.

Modified - this service involves the analysis of a school district's present mathematics program. The PRIMES file can be used to analyze the content and objectives that are currently being taught in the school district at each grade level. The school district may utilize this analysis to develop in-service workshops, to select tests that are related to the current textbook program, and to purchase instructional materials from other series that will supplement the current program.

General - the center offers a general service to all school districts in its service area to strengthen the elementary school mathematics curriculum. This would include services such as answering queries, advising on developing an in-service program, and locating personnel for conducting workshops.

Personnel. Each center has a project director, a mathematics curriculum adviser, and clerical staff. Providing the curriculum services is the responsibility of the mathematics adviser.

Facilities. The regional center provides a meeting room for individual study and for group meetings. It also has sets of the book-form indexes, the master authority lists, the aperture card file, sets of features, the original published basal series, sample curriculum guides, samples of criteria used in textbook selection, a microfilm reader-printer, and duplicating equipment.

Cooperating schools. Five school districts are receiving in-depth service and are utilizing PRIMES materials. They are Penn Trafford, Franklin Area, Greensburg-Salem, Kiski Area, and Southmoreland. These are all being serviced by the regional office at Greensburg, Pennsylvania (Figure 18).

APPLICATION OF PRIMES

Four programs, utilizing PRIMES, have been conducted for school personnel:

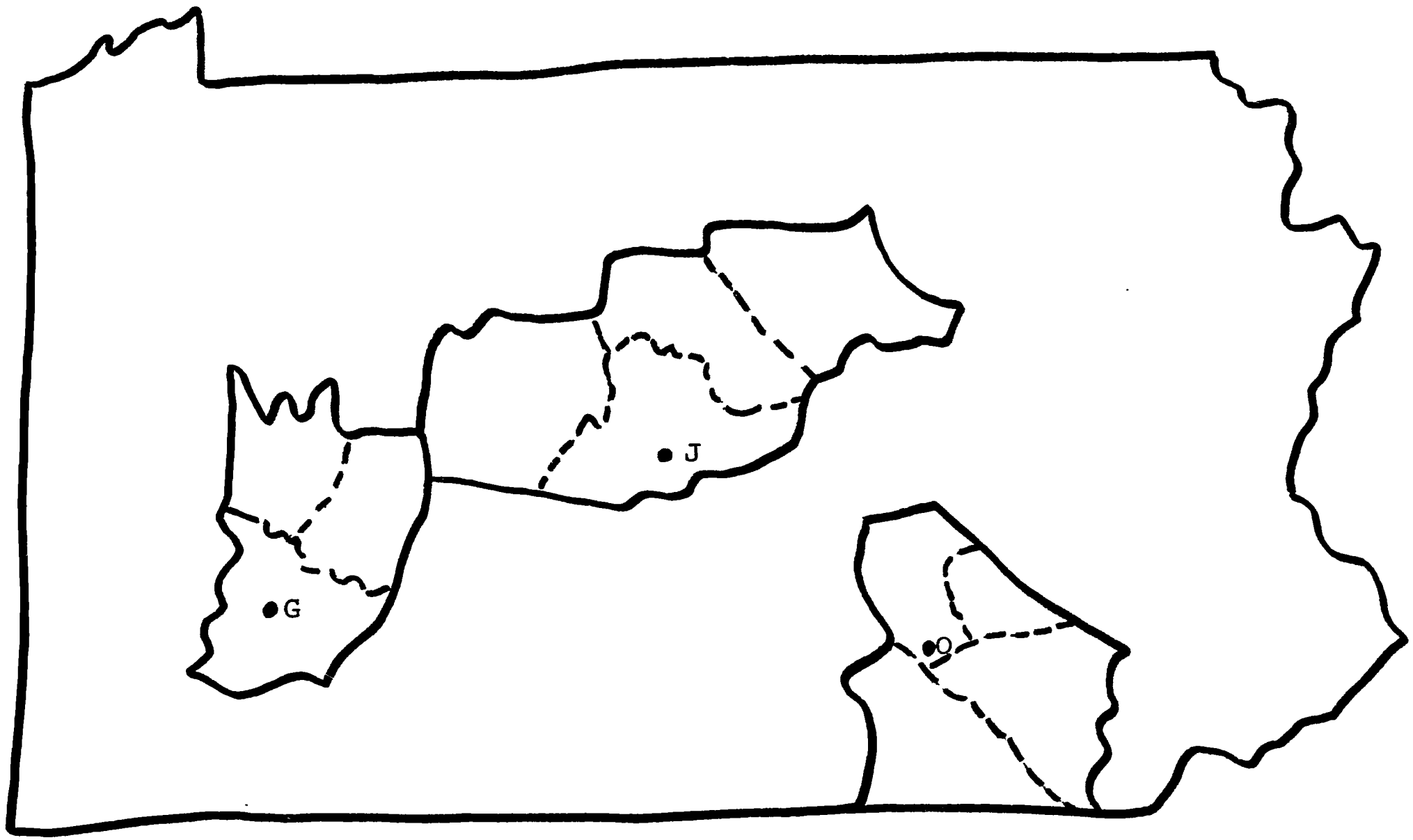
Workshop for Elementary School Personnel. A two-week workshop, June 19-30, 1967, was conducted at the Greensburg Center, University of Pittsburgh, to train teachers and curriculum coordinators to apply PRIMES in curriculum decision-making. Graduate credit was given for participating in this program. Participants were taught the mathematics concepts in the Content Authority List. Laboratory experience was also provided in searching the file, selecting and studying the aperture cards, and analyzing the original published materials. Curriculum development activities were simulated and selected lessons were sequenced for individualizing instruction.

Pre-service Training. Two of the PRIMES analysts have informally utilized the file and the indexes in their undergraduate course in the teaching of elementary school mathematics at West Chester State College and Indiana University of Pennsylvania.

Conference for Secondary Teachers on Elementary Mathematics, Indiana University of Pennsylvania. This conference was organized to train secondary mathematics teachers to service as coordinators of mathematics teaching in the elementary schools. PRIMES was presented to them and they were invited to utilize its services in their future activities.

FIGURE 18

PRIMES REGIONAL CENTERS



Region G - Greensburg
Region J - State College
Region O - Harrisburg

Institute for Instructors of In-service Education in Mathematics. One-week institutes were conducted at three of the state colleges for secondary or elementary teachers who have had recent college courses in mathematics. These participants were instructed in procedures and materials for conducting in-service workshops for the elementary teachers of their local school districts. An orientation session to PRIMES was conducted at each institute and the participants were invited to utilize the products and services of the system in their in-service teaching responsibilities.

DISCUSSION

This study is a description of the development of products and their application in servicing local school districts. Limited experience with PRIMES in dealing with curriculum problems precludes a discussion of the system's effectiveness.

LIMITATIONS

Limitations that are discussed are those which PRIMES staff anticipates in utilizing the file. The staff has consulted with experienced people in the field of teacher training and curriculum development. The general evaluation is that the materials are far more extensive and promising than anything that has yet been developed. Its effectiveness in affecting curriculum development work will be determined by the ability of school personnel to use the system.

The specific areas in which there is need for additional experience are:

Training of personnel. To use the file effectively it is necessary that elementary school personnel understand both the master authority lists. This would require an in-service workshop consisting of about 30 hours of instruction. Extensive use of the file would present a considerable logistics problem in establishing workshops that are convenient to the teachers. There is also the problem of identifying capable instructors who are familiar with PRIMES and who are available to conduct workshops.

File utilization in curriculum activities. The data base in the file is extensive. In curriculum decision-making it would be necessary to select appropriate data related to the needs of a given school district. It may be necessary to provide each of the participating school districts with extensive staff support to assist them in making effective use of the file. This may very well limit the number of school districts that can participate in in-depth service.

Local school district resources. To avail themselves of the in-depth service local school districts need to provide the necessary time for the teaching staff to participate in a training workshop and to attend committee meetings dealing with curriculum development and materials selection. The school district would have to secure substitute teachers to

replace the participants. An alternative is for the school district to compensate the teachers for the time spent after the completion of the school day or during the summer for this additional work. The school district should also provide the funds for instructional costs in conducting the workshop.

Currency of data base. The effectiveness of the file is based on its completeness in providing the analysis on all basal mathematics programs. It is estimated that basal textbook programs are revised at the rate of approximately three per year. Consequently, the system needs to be updated as new programs are published. This requires a complete revision of the indexes, review of authority lists, and microfilming the documents file to include the new programs.

Format of indexes. To utilize the system it is necessary to be familiar with the authority lists. It is impractical to browse in the file and select items of interest. To do this it would be necessary to develop another format for the authority lists. One possibility is using the "keyword-in-context" format which would provide an entry into the system via words that are familiar to untrained users.

ERROR SOURCES

No systematic attempt has been made to identify the frequency of errors or the types of errors that occur in the file. Proofreading randomly selected microfilmed documents for grades K-2 suggests that there are two types of errors - chance errors and those due to difference in judgment among the analysts.

Chance errors. These may be due to mistakes made in transcribing numbers from the original textbooks in which the analysts have indicated the code numbers to the summary forms. Also, there is a possibility that there are errors due to keypunching.

Errors due to judgment. Discussions with the analysts revealed that there are a number of items on which there is disagreement insofar as coding lessons are concerned. PRIMES staff is aware of the need for both a reliability and validity study for both of the master authority lists. The content analysts have participated in an inter-judge reliability study. There are also plans to study the validity of the content item assignment utilizing the

judgment of the senior mathematics editor as the criterion. It is expected that further utilization of the file will tend to identify errors. Plans have already been made to correct any errors that are found.

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The statements in this section are tentative since there has been limited time to experiment with the utilization of PRIMES. However, the use of PRIMES to date has been studied by consultants and experienced school administrators. Their recommendations are that the system be applied and additional data be collected to further evaluate its effectiveness. The discussion under CONCLUSIONS deals primarily with the development of the file and the supporting tools.

CONCLUSIONS

The development of the microfilm document file and the accompanying reference tools support these conslusions:

1. IT IS FEASIBLE TO DEVELOP MASTER AUTHORITY LISTS OF CONTENT AND BEHAVIORAL OBJECTIVES FOR ANALYZING PUBLISHED CURRICULUM MATERIALS IN ELEMENTARY SCHOOL MATHEMATICS.

2. IT IS FEASIBLE FOR QUALIFIED ANALYSTS, WORKING INDEPENDENTLY, TO APPLY THE AUTHORITY LISTS TO PUBLISHED CURRICULUM MATERIALS.

3. THE COMPUTER IS AN EFFECTIVE MEDIUM FOR PRINTING FORMAT-TYPE PAGES IN CURRICULUM MATERIALS ANALYSIS, PRINTING EXTENSIVE INDEXES, AND PROVIDING A METHOD FOR UPDATING AUTHORITY LISTS PERIODICALLY.

4. MICROFILMING ORIGINAL PUBLISHED MATERIALS ON APERTURE CARDS AND IDENTIFYING THE CARD CONTENT IS AN EFFICIENT METHOD FOR STORING AND RETRIEVING A LARGE VOLUME OF PRINTED CURRICULUM MATERIAL.

5. A STATE EDUCATION AGENCY IS IN A STRATEGIC POSITION TO PROVIDE LEADERSHIP IN UTILIZING NEEDED RESOURCES, PERSONNEL, AND FACILITIES THAT ARE LOCATED AT DIFFERENT AGENCIES, IN DEVELOPMENT AND UTILIZATION OF A CURRICULUM INFORMATION SYSTEM.

IMPLICATIONS

The major emphasis to date in PRIMES has been using the document file as an auxiliary tool in curriculum development activity.

The other applications that are suggested in this section would require additions to the present system but would be based on the developmental work that has already been completed.

Aid in developing pre-service and in-service courses for teachers. Laboratory activities using several of the file's components could be incorporated into a course for prospective teachers. In-service programs are most effective when related to the adopted text. Using the file's content and behavior lists for the series adopted would provide the school district with a guide for developing an in-service program that relates to its basal series.

Aid in individualizing instruction. The file would be a useful tool in developing a sequence of both content and behaviors to individualize the mathematics program for each pupil. It would also identify materials that present these concepts in a variety of ways. A pupil who has not mastered a concept presented in one way could be directed to published materials that presented these ideas in a different manner.

Aid in development of teacher-made tests or selection of standardized tests. The behaviors for each of the published programs in the file are an important tool that could help the teacher to develop tests that are appropriate for his class and program. Standardized tests can be selected that include the majority of content and behaviors for the instructional materials.

Aid in placement of transfer pupils. The detailed analysis of both content and behaviors of existing mathematics programs will assist the teacher in identifying both the concepts that a pupil has been previously taught as well as those which are new. The teacher can then develop a program that fills the gaps in a pupil's background.

Assist in a comparative analysis of published programs. Through the use of printed indexes, this system will provide a tool for comparing published programs. Comparisons can be made on the basis of content, behavioral objectives, problems or exercises provided for the pupil, and the type of concept development recommended.

RECOMMENDATIONS

PRIMES has concerned itself with the elementary school mathematics curriculum and has devoted its efforts to analyzing basal programs for the elementary grades. The experiences gained in the course of this project can be applied to adding new components to the information file, extending the project to include grades 7 to 12, and applying the procedures with appropriate modifications to other curriculum areas. The project has also explored developing a state plan for a total curriculum consulting service and utilizing the computer to assist in communicating with the local school districts.

It is suggested that consideration be given to these recommendations:

Adding components to PRIMES file. There is need for analyzing and storing information relating to these curriculum materials - audio-visual, enrichment materials, and standardized tests. There is also need for a comprehensive survey of curriculum practices in elementary school mathematics, analysis of experimental research studies, and summaries of important professional literature of interest to the classroom teacher. Consideration should be given to identifying creative efforts of teachers and encouraging them to submit their materials to PRIMES for dissemination.

Extension of PRIMES to include grades 7-12. There are a large number of textbooks and instructional materials that are utilized in the teaching of mathematics in the secondary school. There is need for developing the analysis tools and applying them to these materials to assist the secondary school teachers in their curriculum development activities.

Other curriculum areas. There is great interest in developing a system for analyzing curriculum materials in such areas as elementary school science, reading, and social studies. Developing analytic tools and procedures are necessary to implement these activities.

State plan for curriculum services. The Department is in a position to coordinate the activities of these state education agencies - the area curriculum centers, county offices, state colleges, and state-related universities - in advising local school districts in their curriculum development activities. The state is not in a position to retain a large staff for the purpose of consulting with the approximately 500 school districts throughout the Commonwealth. Coordinating the activities of the state-associated education

agencies could conceivably provide the resources in regional locations that are convenient to the school districts requesting curriculum assistance.

Computer application to curriculum services. Use of the display devices in conjunction with the computer is now a reality. PRIMES might be able to develop a system that would provide for schools accessing a computer directly with queries related to the curriculum file.

SUMMARY

"The Development of an Information System for Elementary School Mathematics Curriculum Materials: A Feasibility Study" is a project concerned with applying the technology of information storage and retrieval to curriculum materials that are in use in the public schools of the Commonwealth of Pennsylvania. School districts are faced periodically with a need to select an elementary mathematics text series. Few school districts have either the time or the resources to develop comprehensive curriculum guides and accordingly select instructional materials. The magnitude of the task of examining published textbook materials is illustrated by the fact that there are approximately 30,000 pages of published pages that comprise the basal programs for elementary school mathematics.

This project is based on the assumption that much of the basic analytical work can be done centrally by a state education agency and the results of these efforts can then be disseminated to interested school districts. Another principle that has influenced the development of the system is that the tools will be made available to local school personnel to assist in curriculum decision-making. The system is not intended to recommend specific basal programs for use.

The system proposed to accomplish three major objectives:

1. Developing a system for analyzing, storing, and retrieving information related to elementary school mathematics curriculum materials.

2. Developing procedures for utilizing the system for curriculum decision-making by local school districts.

3. Evaluating the effectiveness of the system in accomplishing its purpose.

Some applications of the materials developed by the system are constructing curriculum guides, selection of a basal textbook series, and selection of appropriate supplementary materials.

This project was concerned with these objectives - developing a document file and using the file in working with local school districts in their curriculum development activities.

Document file. A system document consists of three basic elements - the analysis sheet, the teacher manual page, and the pupil text page. Each page of twenty published elementary mathematics basal series has been analyzed using these categories - content, expected pupil behavior, type of

problem, vocabulary and symbolism, grade level, pre-text activity, and post-text activity.

Assignment of content to each of the lessons was based on the Content Authority List which is a master list of about 300 mathematics concepts and skills developed by a committee of nationally recognized mathematics educators. The behavioral objectives were assigned from a list of approximately 1500 pupil objectives that was developed by members of the staff of the Learning Research and Development Center, University of Pittsburgh. Content analysts were professors of mathematics at colleges or universities in the Commonwealth. Seven experienced classroom teachers were trained and supervised by the authors of the Behavior Authority List in applying this list to the published lessons.

Another component of the document file is the features that describe a given program. Each of the features described can be documented with a page reference.

Servicing school districts. To service local districts, the project has cooperated with other educational agencies in organizing two regional centers. These centers are responsible for providing local school districts in their geographic area with consultative services following procedures developed by the central system. Each of the centers is staffed with an elementary mathematics adviser and supporting clerical personnel and are supplied with the document file, indexes, original basal series, and the authority lists. Periodically, evaluation conferences are conducted to identify problems and to suggest solutions to increase the efficiency and effectiveness of the services to the local school districts.

The results of this project can be described under products, services, and application of the PRIMES materials.

Products

Microfilm File. The microfilm file consists of approximately 25,000 aperture cards. Each card has an accession number identification and the grade level at which the lesson is taught.

Content Authority List. This list consists of approximately 300 mathematics concepts and skills that may be taught from kindergarten through grade six. The items are arranged in hierarchical order with a unique number assigned to each of the items.

Behavior Authority List. This list consists of approximately 1500 objectives for elementary school mathematics stated in behavioral terms.

The system has compiled two master indexes - the Master Context Index and the Master Behavior Index. The indexes make possible identification of relevant accession numbers according to requested content or behavioral objective.

Vocabulary and Symbolism Lists. The system has compiled a draft of the technical vocabulary and symbolism which are used in the published programs. In addition, there is a vocabulary and symbolism summary for each of the basal textbook series.

Features. Each of the books is described in an objective style and is documented with a page reference. These features are based on an outline which includes such characteristics as organization, scope, sequence, and the development of the mathematics content.

Consultative Services - Regional Centers. There are now two regional centers established to use PRIMES materials in working with local school districts. Three levels of consultative curriculum services are offered to interested school districts. These are:

In-depth Service. This refers to a comprehensive study of the school's current elementary mathematics curriculum, constructing a new curriculum guide, and selecting appropriate instructional materials to implement this guide.

Modified Service. This involves a comprehensive analysis of a school's present mathematics curriculum.

General Service. This includes answering individual questions, advising about in-service programs, and identifying competent personnel to assist in activities to improve the mathematics curriculum.

Application of PRIMES in Training School Personnel. PRIMES personnel have participated in the training of elementary school teachers and students who plan to enter the teaching profession. These programs are:

Workshop for Elementary School Personnel. A two-week workshop conducted at the Greensburg Center, University of Pittsburgh, to train teachers and curriculum coordinators to apply PRIMES in curriculum decision-making.

Methods of Teaching Elementary Mathematics. Two PRIMES analysts have utilized the system's materials in undergraduate courses.

Conference for Secondary Teachers on Elementary Mathematics. This conference was conducted at Indiana University of Pennsylvania to train mathematics teachers to serve as coordinators of mathematics teaching in the elementary schools.

Institute for Instructors of In-service Education in Mathematics. One-week institutes were conducted at three of the state colleges for secondary and elementary teachers who have had recent college courses in mathematics.

The development of the microfilm document file and the accompanying reference tools supports these conclusions: (1) a state education agency is in a strategic position to coordinate the analysis of a large volume of curriculum materials. It can utilize diverse talents at key agencies to develop the appropriate analytic tools, to implement the materials analysis, and to produce a document file; (2) it is feasible to apply the techniques of information storage and retrieval to educational curriculum materials and develop a system that is flexible in responding to local school district requirements, and (3) servicing local school districts should be done on a decentralized basis.

Developing a comprehensive curriculum materials data base has implications for other requirements in building a total curriculum. The curriculum materials can be related to in-service workshops for teachers, individualizing instruction, developing valid teacher-made tests, selecting appropriate standardized tests, and assisting schools in placing and teaching students who transfer from other districts.

PRIMES has concerned itself with developing an information system in the area of elementary school mathematics curriculum materials. The effectiveness of this system supports the following recommendations:

Adding components to PRIMES file. Consideration should be given to developing techniques for storing relevant information with regard to such materials as audio-visual, enrichment, and standardized tests.

Extending of PRIMES to include grades 7-12. School districts have expressed interest in securing information about materials that would assist them in designing a comprehensive mathematics curriculum for grades kindergarten through grade 12. It is suggested that study be made of PRIMES procedures so that the system would include secondary curriculum materials.

Developing information systems for other curriculum areas. There is need in other curriculum areas for developing analytic tools, applying these to curriculum materials, and systematically storing and retrieving the information.

Developing plans for state-wide curriculum services. School districts would be receptive to a state-wide plan that would provide them with expert services in dealing with their curriculum problems. These services should be based on a comprehensive data base and be responsive to local needs. The state could utilize the existing state-related educational agencies in implementing this recommendation.

Applying computer technology to curriculum services. Methods for utilizing the computer to deal with the "information explosion" in published curriculum materials should be explored. This includes developing the components of an information system and providing ready access to the information for local school districts.

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2. Barhydt, Gordon C. Western Reserve University Computer Index of Educational Research. Cleveland: Western Reserve University, 1964.

3. Center for Documentation and Communication Research. A Selected Bibliography of Documentation and Information Research. Cleveland: Western Reserve University, 1964.

4. Christian, William C. "Retrieval System Disseminates Medical Information," Systems. 7, November 1966, pp. 16-17, 54.

5. The Knowledge Availability Systems Center. Space and Technology Transfer. Pittsburgh: University of Pittsburgh, n.d.

APPENDIX A

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APPENDIX B

BASAL TEXTBOOK PROGRAMS IN FILE

Publishers	Grades
1. Addison-Wesley Publishing Co., Inc. Elementary School Mathematics Eicholz, Daffer, Brumfiel, Shanks - 1963	K-6
2. American Book Company Elementary mathematics series Deans, Kane, Oesterle - 1965	1-6
3. Encyclopaedia Britannica Educational Corporation Math Workshop Wirtz, Botel, Beberman, Sawyer - 1964	K-6
4. Ginn and Company Mathematics We Need Brownell, Weaver - 1965	1-6
5. Harcourt, Brace and World, Inc. Elementary Mathematics Clark, Beatty, Payne, Spooner - 1965	K-6
6. D. C. Heath and Company New Ways in Numbers Elwell, Sister M. Stanislas, Fitzgerald - 1965	1-6
7. Holt, Rinehart and Winston, Inc. Moving Ahead in Arithmetic Merton, Brueckner, Grossnickle - 1963	K-6
8. Holt, Rinehart and Winston, Inc. Elementary Mathematics: Patterns and Structure Nichols, Flournoy, Kalin, Simon - 1966	1-6
9. Houghton-Mifflin Company Modern School Mathematics: Structure and Use Duncan, Capps, Quart, Dolciani, Zweng - 1967	K-6

10. Laidlaw Brothers — K-6
    Sets, Numbers, Numerals
    Gundlach, Welch, Buffie - 1965

11. McCormick, Mathers Publishing Company — K-6
    The New Arithmetic
    Weber, Weber - 1963

12. McGraw-Hill Company (Webster Division) — K-6
    Elementary Mathematics: Concepts, Properties, and Operations
    Spitzer, Banks, Burns, Kohrs, Folsom - 1967

13. Charles E. Merrill Books, Inc. — 1-6
    Discovering Mathematics
    DeVault, Osborn, Swenson - 1964

14. William H. Sadlier, Inc. — 1-6
    Contemporary Progress in Mathematics
    Bezuszka, McDonnell - 1965

15. Science Research Associates — K-6
    Greater Cleveland Mathematics Program
    Education Research Council of Greater Cleveland - 1962

16. Scott, Foresman and Company — 1-3
    Seeing Through Arithmetic
    Hartung, VanEngen, Gibb, Stochl, Knowles, Walch - 1965

17. Silver-Burdett Company — K-6
    Modern Arithmetic Through Discovery
    Morton, Gray, Rosskopf - 1966

18. L. W. Singer Company — K-6
    Sets and Numbers
    Suppes - 1965

19. School Mathematics Study Group — K-6
    Mathematics for the Elementary School
    Panel on Elementary School Mathematics - 1965

20. Xerox Educational Division — 1-3
    Mathematics Laboratory Materials
    Rasmussen, Hightower, Rasmussen - 1964

APPENDIX C

FILE PARAMETERS

DOCUMENT FILE (Kindergarten to Grade 6)	
Number of programs	20
Number of books	131
Number of pages/book	300
Total number of pages (Kindergarten to Grade 6)	39,300
Number of aperture cards (200/book)	26,200
Number of 35-mm rolls	65
Cost per duplicate 35-mm set ($6.00/roll)	$ 390
Cost per duplicate aperture card set	$1,500
Estimated number of 18x24 prints - Harrisburg	20,000
Estimated number of 18x24 prints - regional center	10,000
BEHAVIOR AND CONTENT AUTHORITY LISTS	
Number of categories	1,800
Number of pages/listing	100
Frequency of updating	4
Levels of indention	7
INDEX FILE	
Average number of index entries/lesson	8
Total number of index entries	320,000
Number of pages/book-form index (40 entries/column on a two-column page)	4,000
Cumulative supplements	4
Number of pages/supplement	2,400