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ABSTRACT

A prototype computer-based instructional management system is described which is designed to individualize instruction in an on-going school situation. The prototype consists of three basic components: a set of instruments and techniques for assessing student needs, a bank of curriculum packets related to assessed needs, and a computer-based system for relating individual needs to available curriculum options. The student evaluation system consists of terminal measures, diagnostic tests, measures of learner characteristics, and progress tests. Curriculum packets are coded in nine ways to provide a practical basis for structuring the learning experiences of students and still allow considerable flexibility for changes and the addition of new material. A computer matching system prescribes an individualized learning path for each student by matching the student's assessment file to the curriculum catalog. In addition to instructional management, the system can also assist in research and evaluation and in administrative management. The prototype has been used at the Center for Individually Prescribed Learning Activities at Conwell Middle Magnet School in Philadelphia. A discussion of their experience in using the system demonstrates its potential for solving educational problems. (JY)

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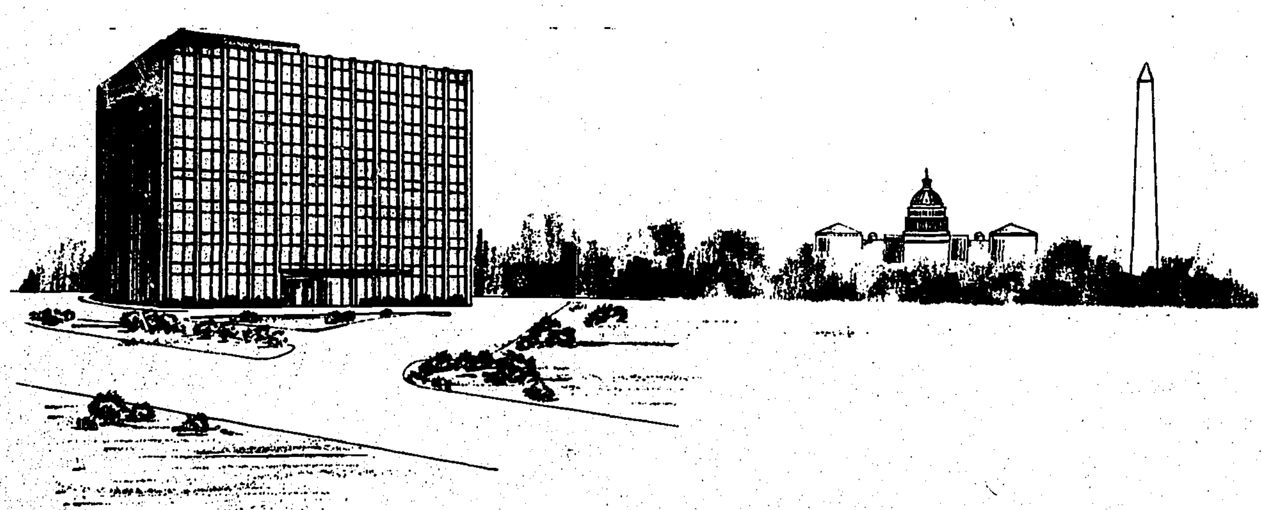
John A. Connolly

Interim Report

NOVEMBER 1970



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A COMPUTER-BASED INSTRUCTIONAL MANAGEMENT SYSTEM: THE CONWELL APPROACH

John A. Connolly

INTERIM REPORT

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ABSTRACT

The report describes the prototype of a computer-based instructional management system designed to individualize instruction in an on-going school situation. The model consists of three basic components: a set of instruments and techniques for assessing student needs, a bank of learning packets related to assessed needs, and a computer-based system for relating individual needs to available curriculum options. The development and operation of each of these components is detailed.

Various applications of the model are examined including the use of the system as: a program of instructional management, a tool for research and evaluation, and a vehicle for administrative management of a school. Techniques for dissemination of the prototype are also explored.

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INTRODUCTION

Educators, not too long ago, began to view the computer as a potentially powerful helpmate in their efforts to develop the individual capabilities of each student. After all, industry had formed a strong partnership with computers. Why not education?

Baker (1970) reviews the early attempts to apply computers to education while taking a critical "first look" at the major computer based instructional management (CBIM) systems.[1] Educators first became infatuated with the notion of assisting the instructional process by means of direct interaction between the student and a computer. Activities in this area have tended to demonstrate the feasibility of computer assisted instruction (CAI) but not its practicality or educational validity, and the initial flush of enthusiasm has gradually subsided. Attention is now turning to programs designed to manage the educational process with the aid of computers. The promise of CBIM systems far exceeds the actual accomplishments to date. A lasting marriage between computers and education is still a long way off.

The purpose of this report is to describe another CBIM system which tends to differ from most ot systems in four major respects. First, the system focuses exclusively on basic minimum objectives in various subject-matter fields rather than encompassing a complete curriculum in mathematics, science, communication arts, or social studies. Second, the system is designed for maximum flexibility in responding to unique sets of objectives which are developed in the local school setting instead of trying to impose a common set of objectives on all schools.

Third, there is an effort to assist students in attaining a minimum standard of maturity in a variety of affective as well as the more traditional cognitive objectives. Fourth, the system attempts to adapt instructional treatments to individual differences in children while simultaneously individualizing instruction by guiding the student through an instructional program at his own pace and sequencing the instructional units in the light of his progress.

OVERVIEW

The basic objective of the project is to develop a prototype of individualized instruction with specific reference to the operational conditions in a single school situation and then to disseminate the model to other interested schools. The model ultimately should serve as a basis for constructing a network of learning centers in a number of schools, all tied together by remote terminals and serviced by a central computer-managed system of individually prescribed learning activities.

The prototype was developed by AIR personnel at Conwell Middle Magnet School, a poverty area school located in Philadelphia, under a Title III grant. Any attempt at a complete description becomes quickly dated since the system is still under development in many respects. Nevertheless, the major components are operational and firm in overall design.

The model will provide maximum flexibility for adapting the components of the system to the special conditions of each local school situation. Each school determines its own objectives, measures, and curriculum approaches using the techniques and materials developed in the project as a starting point. These specially tailored components are fit into a common computer-based system for managing the learning process. Every school has a continuing responsibility for developing the system by contributing better ways to assess student needs, improved curriculum alternatives, and more effective means for matching needs to alternatives. In turn, each school draws from the system according to its special needs.

THE BASIC SYSTEM STRUCTURE

In simple terms, the system under development is designed to find out what children need and to supply the most appropriate learning experiences to meet these individual needs. The prototype consists of three basic components: a set of instruments and techniques for assessing student needs, a bank of curriculum packets related to assessed needs, and a computer-based system for relating individual needs to available curriculum options. This report is an explicit presentation of the development and operation of each of these three components.

I. Student Evaluation System

Individual treatment begins with an evaluation of the strengths and weaknesses of each student. The evaluation system is designed to determine what the child needs to learn, which is the most effective way to teach each child, and whether the student has learned the materials which were presented. Chart #1 shows the four major kinds of measures used in the evaluation system.

CHART #1

General Description	Purpose	Focus	Type of Measure	When Administered	How Constructed	Data Bank Input
Terminal Measures	To determine mastery of basic school objectives	CONTENT CATEGORIES Communication Arts (8 Objectives) Mathematics (10 Objectives) Science (13 Objectives) Social Studies (7 Objectives) SKILL CATEGORIES Creative Thinking (4 Objectives) Critical Thinking (5 Objectives) Effective Communication (5 Objectives) Effective Social Behavior (5 Objectives) Learning Strategy (5 Objectives) Personal Responsibility (5 Objectives)	Test Test Test Test Self & Teacher: Rating Rating Rating Rating Rating Rating	A. Spring ...To all students B. When prerequisite segments are completed C. On request of student or teacher	Teachers...AIR	For each objective: 0. = Deficiency 1. = Mastery
Diagnostic Tests	To indicate appropriate learning segments for students who have not yet reached mastery on particular objectives	One for each objective	Test	When student selects objective from list of priorities	Teachers...AIR	For each segment 0 = Fail 1 = Pass
Measures of Learner Characteristics 0 0 0 0	To measure individual differences in learning characteristics 0 0 0 0	Reading Level 0 Aptitude 0 Learning Style 0 Cognitive Style 0	Published Tests 0 Published Tests 0 Test 0 Published Tests 0	Spring 0 Spring 0 Fall 0 Fall 0	Published 0 Published 0 AIR 0 Published 0	0 = 0-2nd year 1 = 3-5 year 2 = 6 and above 3 = No information 0 = Below average 1 = Average or above 2 = No information 0 = Visual 1 = Auditory 2 = Kinesthetic 3 = Mixed 4 = No information 0 = Concrete 1 = Abstract 2 = No difference 3 = No information
Progress Tests	To determine if the material in the packet was learned	One for each packet	Test	Upon completion of packet	Teachers...AIR	For each packet: 0 = Fail 1 = Pass

STUDENT EVALUATION SYSTEM

A. Terminal measures. Meaningful evaluation depends on a firm definition of educational objectives. This system focuses exclusively on basic school objectives which are defined as the minimal outcomes of a middle school educational experience (Grades 5-8). Some of the sources used to identify potential objectives include the taxonomies of educational objectives (Bloom, 1956; Krathwohl, 1964), materials from the Instructional Objectives Exchange, lists of objectives obtained from other projects, and the curriculum guide for the Philadelphia School District.

Conwell teachers defined their school objectives by identifying those facts, principles, and operations that they expect every student to remember, understand, or perform by the time he completes four years of instruction in mathematics, science, social studies, and communication arts. An example is one of the mathematics objectives called "arithmetic skills," which defines a level of addition, subtraction, and multiplication which is expected of every student.

Added to such content objectives were a series of "skill" objectives defining the minimal levels of proficiency in more general skills which cut across the various subject-matter areas. One example, under the general area of "Learning Strategy," is "independence in learning," defined as the ability to take an assignment requiring the use of reference materials, locate the designated materials in the library, obtain the required information, and report it in a reasonably coherent manner. A number of affective as well as cognitive objectives are included in the "skill" category such as "tolerance of individual differences," "empathy toward others," and "educational interests."

The process of defining objectives at Conwell resulted in the establishment of 38 content and 29 skill objectives. These are the foundation stones of the system's curricular content and direction. These objectives are subjected to review and revision each year when the teachers reconsider their basic minimum objectives in light of the previous year's experience.

The next task involved the development of measures of mastery of these basic school objectives. Tests were written for all content objectives, and rating scales (to be used by both the students and teachers) were developed for evaluating students with reference to the skill objectives. These terminal measures are scored according to a predetermined criterion of mastery. Following the assessment process, the student data bank indicates each student's current mastery or non-mastery of each objective.

B. Diagnostic tests. Diagnostic tests are used to help determine which of the available learning materials the student should be assigned. Mastery of most of the basic objectives requires the student to perform or comprehend a number of component operations or concepts, each representing one segment of the total objective. For example, the concept of place values in numbers is one component of Arithmetic Skills. The diagnostic test attempts to determine which segments of the objective, among those available for presentation in packet form, have already been mastered by the student and therefore should be eliminated from his learning prescription. The test items are taken from the progress tests (see below) which are found at the end of each learning packet.

C. Measures of learner characteristics. The psychology of individual differences suggests that children will learn best when taught in a way that conforms to their particular learning characteristics (Gagné, 1967; Cronbach, 1957). Four variables are measured which seem to represent important dimensions of learning ability.

1. Reading level. Standardized test results are used to indicate a student's reading level. The test results are categorized in one of three levels and entered in the student's evaluation file.

2. Aptitude level.[2] Scores from mental ability tests are categorized as "below average" or "average or above" for input into the student file.

3. Learning style. Three distinct sensory pathways - the visual, auditory, and kinesthetic - convey most of the information from which the student learns. Research (Myers and Hammil, 1969) has suggested that some children have strengths or weaknesses in learning by means of one or another of these pathways. "Learning style" is defined as the profile of the student's relative ability to use and remember information processed through the three modalities. Instruments have been constructed which determine the child's learning style by

presenting comparable learning tasks (i.e., paired-associates) through visual, auditory, and kinesthetic means and requiring subsequent recall or recognition of the stimuli.

4. Cognitive style. There is also some suggestion in the literature (Guilford, 1959; Flavell, 1963; Jensen, 1969) that children's mental processes may be especially suited to learning either abstract or concrete relationships. For example, one student might find the learning of number systems facilitated by a considerable amount of practice with numbers, while another student might need to be taught only the principles involved. Measures of these abilities consist of the Raven's Progressive Matrices for abstract learning and a memory for numbers test for concrete learning.

D. Progress tests. These tests are designed to measure mastery of the material presented in each learning unit. A variety of testing techniques are employed including objective items, written response items, and discussions with the student. Whatever the testing technique used, a "pass-fail" decision is always reached for every packet the student completes. These data are entered into the student file as they become available.

In summary, then, two kinds of measures produce about 80 different scores for every student indicating his mastery or deficiency with reference to 67 basic objectives and his individual strengths and weaknesses in terms of four learning characteristics. Two other kinds of instruments, diagnostic and progress tests, are administered to a student as he pursues a particular learning objective and the results are entered in his file as they become available.

II. Packet Coding System

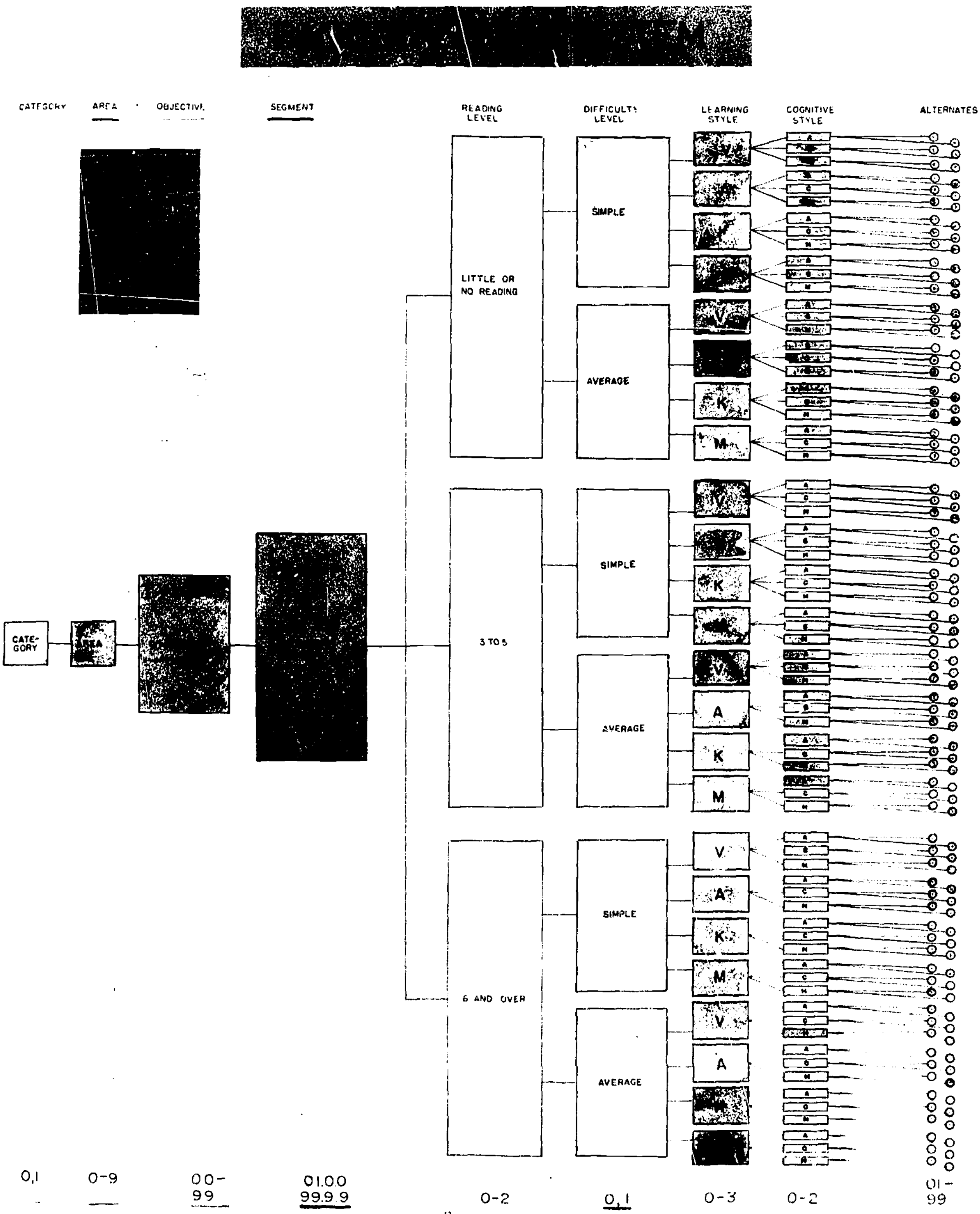
The system for coding learning packets into a curriculum data bank is shown in Chart #2. The bank provides a variety of curriculum alternatives for training toward mastery of each of the basic objectives. The chart is used by teachers in the coding of learning packets and also serves as a guide to curriculum development.

A packet is defined as a curriculum unit involving independent or semi-independent learning activities. Each packet consists of a statement of the packet objectives, a unit of instructional material, and a progress test. Some packets were developed by the local school teachers or project staff members and others were adapted from external curriculum materials. Approximately 700 packets are currently available.

A. Packet coding. Packet coding relies heavily on teacher judgment. Teachers in the various subject-matter fields are directly responsible for reviewing all packets in their area and coding these materials into the system. Every packet is coded in terms of the nine characteristics shown across the top of the chart using the code-number ranges shown along the bottom.

1. "Category" is a dichotomous variable indicating whether the packet teaches toward a content or a skill objective. A packet on place values, for example, would be coded "1"

CHART #2


CATEGORY
AREA
OBJECTIVE
SEGMENT
READING LEVEL
DIFFICULTY LEVEL
LEARNING STYLE
COGNITIVE STYLE
ALTERNATES
CATE-GORY
LITTLE OR NO READING
3 TO 5
6 AND OVER
SIMPLE
AVERAGE
V
A
K
M
0,1
0-9
00-99
01.00 99.9 9
0-2
0,1
0-3
0-2
01-99

8a

indicating a content objective.

2. "Area" is coded to specify the general content area of the packet (e.g., communication arts, creative thinking).

3. "Objective" is one of the 67 basic objectives. The coding system provides for later additions to the list.

4. "Segment" indicates the specific concept or topic which is taught in the packet and the relative order of its presentation in the instructional sequence. Thus, a packet on place values would be given early in an instructional sequence leading toward mastery of the arithmetic skills objective. The teacher in a structured subject-matter field such as mathematics may have a relatively clear conception of discrete segments which lead to mastery and the appropriate theoretical sequence for presenting these segments. In the more typical case, however, the teacher simply recognizes that a child must be presented with one packet at a time in some order and he determines a reasonable sequence to the best of his ability. A decimal system of coding is used to allow the insertion of new segments into the series as they become available.

5. "Reading level" of the packet is classified in one of three categories, as shown in the chart.

6. "Difficulty level" is an index of the complexity of the packet. If, for example, the packet presents the principles of place values in a series of very simple steps with careful explanation

of all the points involved, the packet would be coded at the "simple" level.

7. "Learning style" is a classification of the method used to present the material in the packet. It is possible to teach place values by asking the student to read written materials (visual), listen to a taped discussion of the same material (auditory), or manipulate some tangible object such as an abacus (kinesthetic). The coders are instructed to designate a packet as "mixed" only when there is no clear emphasis on visual, auditory, or kinesthetic presentation.

8. "Cognitive style" is a designation of the instructional process used in the packet. Place values, for example, might be taught in a concrete way involving memorization and practice with numbers or in an abstract manner utilizing the logic of our decimal number system.

9. "Alternates" is a coding variable which is used only when two or more packets have exactly the same code numbers for all other variables. These packets might attempt to teach the same thing in slightly different ways. This variable is used to show that alternate packets are available and to indicate which one should be given to a student first.

B. Guidelines for curriculum development. The same chart can be viewed from an entirely different perspective - one which suggests a strategy for curriculum development. The chart shows 72 hypothetically different ways of teaching the same segment or learning unit.[3] The actual development of so many variations is not practical. Nor would it be desirable at this stage in the development of an untested model. A more practical approach is to devise a strategy for developing some of these packet variations to serve as the basis for testing the usefulness of the coded variables in structuring the learning experiences of children.

Which packet variations are the most likely targets for initial development? This decision depends largely on the nature of the segment under consideration. Some variations can be eliminated simply because it is difficult or impossible to generate learning activities for that topic which conform to the specified characteristics. Of those which remain, some attempt has been made to develop first those packets which accommodate the most frequent requests for materials.

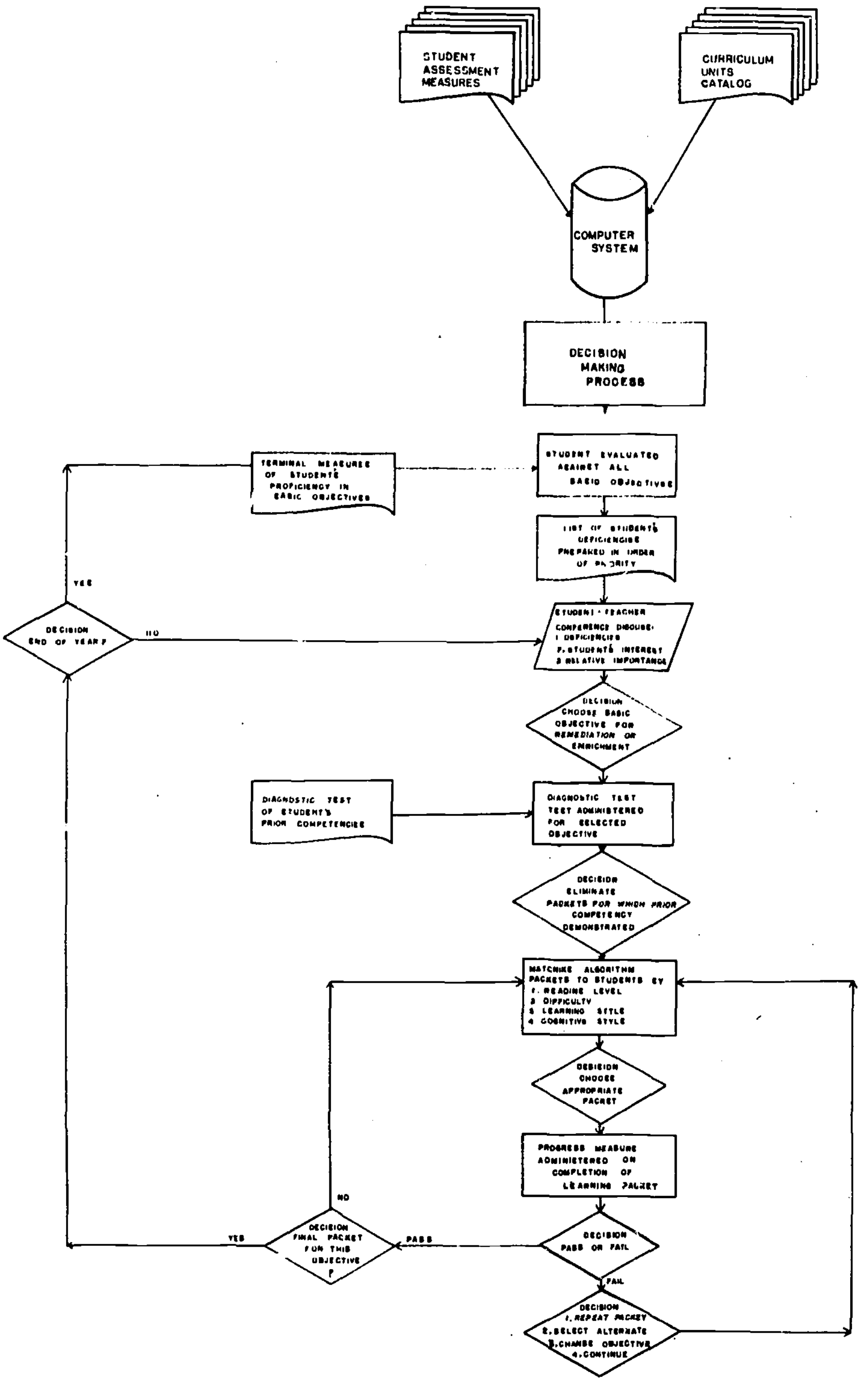
In summary, Chart #2 indicates the nine coding dimensions used by teachers to describe every learning packet for entry into a curriculum catalog. The coding system allows considerable flexibility for changes and the addition of new material. The same chart also suggests a practical strategy for the development of variations in packet materials.

III. Computer Matching System

Chart #3 is a schematic representation of the computerized system for managing the student's learning activities. The system is designed to prescribe a learning path for each student corresponding to his

CHART #3

COMPUTER MATCHING SYSTEM



individual needs by computer matching of the student's assessment file to the curriculum catalog.

A. System configuration. A remote computer terminal (IBM 2740-2) is located in the Center for Individually Prescribed Learning Activities at Conwell School. Telephone lines link the terminal to a 2701 Transmission Control unit at the Philadelphia Board of Education Building. The control unit is attached to an IBM System 360, Model 30 central processing unit with core storage partitioned for multi-programming. The foreground partition, with 14K core storage locations, is dedicated to the CBIM System. The data files are stored on a disk pack mounted on an IBM 2311 disk drive. The operating programs reside on a second, permanently mounted, systems disk pack.

The system operates mainly in the on-line processing mode, with provision for remote batch operation as well. The major on-line request is for new packet assignments. Students request their own packet assignments by interacting with the computer through the terminal and receive virtually immediate decisions. The remote batch mode is used when the full computer system is needed to add a new student to the file, or enter a new objective to the curriculum file. These requests are transmitted during the school day, queued on the disk pack, and processed during the night.

B. Decision making process. The chart shows the flow of the major steps in the decision-making process. The first major decision is the choice of a particular objective for student concentration.

The decision is made in a conference between the student and the supervisor of the Center. Prior to the meeting, the computer lists the student's deficiencies in order of priority for guidance purposes. The priority rating for each objective is pre-determined by the teachers to assure that the most important needs are considered first. The student and the center supervisor, however, can choose to begin work on a low priority objective. Human judgment, in this instance and throughout the system, is always permitted to supersede programmed decision-making.

The next decision point is reached after the student has taken the diagnostic test for the selected objective and the scores have been entered into his evaluation file. The results indicate which packets should be eliminated from the student's prescription.

The third decision is the focal point of the entire system. The rapid selection of the appropriate packet for a particular student at a given point in time is the primary justification for automating the system to utilize the speed of a computer. The packet choice is based on a matching algorithm consisting of six procedural steps, as follows:

1. Search for a <u>perfect</u> match between the student's measured learning characteristics and the coded packet characteristics for an instructional unit. The process begins when a student requests his first packet assignment for a particular objective. The computer relates his reading level, aptitude level, learning style, and cognitive style to the coded dimensions

of the available packet variations for the first unmastered segment in the instructional sequence in an effort to find an exact match. If a packet variation matching all of his measured characteristics is available, the instruction to take that packet is transmitted to the student. If not, the computer moves to the next step in the process.

2. Search for an imperfect match. There is an implicit hierarchy in each of the four dimensions used for coding packet characteristics. Packet variations involving little or no reading, or reading at the 3rd to 5th grade level, for instance, are well within the capabilities of a student who reads at the 6th grade level or above. Similarly, the student with average aptitude can handle materials at a simple level; students with a strength in any of the three learning modes should prove capable of working with mixed learning modes, and the abstract learner can be taught using either a concrete or a mixed presentation. If a packet variation is available that is within the student's capabilities on all four variables, that packet assignment is given to the student. If not, the computer search continues.

3. Search for an imperfect match disregarding the measured cognitive style of the student. At this point the computer is searching for a packet which is within the student's reach using three variables only - reading, aptitude, and learning style. Cognitive style has been eliminated first since its

validity seems least firmly established. Again the student gets an assignment if one can be found.

4. Search for an imperfect match disregarding both cognitive style and learning style. The search is continued with only two variables brought into play.

5. Search for an imperfect match disregarding cognitive style, learning style, and aptitude level.

6. Search for an imperfect match disregarding all four variables. In effect, assign anything that is available on the requested topic.

The next decision point is reached after the student completes the packet assignment, takes the progress test and returns to the center supervisor for an evaluation. The process is relatively straightforward in the "pass" case. The student is told that he has successfully completed the packet, and asked to return to the terminal in order to record the packet completion and get another assignment in the series leading to mastery of a particular objective. When the student has completed the final segment for a particular objective, he is instructed to take the terminal measure. The entire process is then repeated for another objective.

In the "fail" case, the center supervisor must reach one of four decisions. One is to suggest that the student repeat the same packet assignment, perhaps obtaining assistance from a student tutor. Another approach is to suggest that the student request another packet assignment within the same instructional segment. A third decision is to have the student change temporarily to another objective. A final possibility is to tell the student to record an incomplete for the current segment and continue on to the next segment. In all cases, the student returns to the terminal to record the decision reached and to receive new instructions.

C. Interactive language. Perhaps the best way to understand the nature of the computer system is by examining the interactive language. Listed below is a facsimile of the dialogue which is conducted with a student after the successful completion of a packet in order to record his progress and provide the next learning assignment. (In the "fail" case which is not shown, the child is asked another series of questions along the lines described above.) This transaction represents the most frequent use of the terminal during the school day.

COMPUTER: PLEASE TYPE YOUR FIRST NAME, SPACE, AND LAST NAME

STUDENT: CAROL CHAPMAN

COMPUTER: CHAPMAN CAROL ID#0892
CAROL, PLEASE ENTER THE FULL NUMBER OF THE PACKET
YOU HAVE JUST COMPLETED

STUDENT: 1100050005

COMPUTER: HAS THIS PACKET BEEN SUCCESSFULLY COMPLETED?
TYPE IN YES OR NO

STUDENT: YES

COMPUTER: YOUR RECORD NOW SHOWS THIS PACKET WAS COMPLETED
PACKET 1100060007 ASSIGNED, WHY STUDY? (TAPE)
LEVEL 1 MATCH THIS SHOULD BE EASY TO DO.

The final statement in this dialogue bears close examination. The instruction to take a particular learning packet is obtained by matching the student's learning characteristics to the available curricula options using the matching algorithm. The level of the match which was obtained is shown along with a statement to the student about the packet he was assigned. So, for example, when a perfect match is found, the student is told, "This packet is just your style." When only a very poor match can be found, the student receives the instruction, "This packet may be hard for you. Ask for help if you have trouble."

In addition to processing student requests, the terminal and the interactive language are used by the center supervisor to change or display any part of the student file or curriculum file, and to request batch overnight processing. Some of the existing capabilities of the system are shown in Appendix A. The computer is programmed to respond to dozens of different kinds of requests from the center supervisor.

APPLICATION OF THE SYSTEM

The prototype system offers a variety of services to the administrators, teachers, and children at Conwell School. These services involve the use of the system as a program of instructional management, a tool for research and evaluation, and a vehicle for administrative management of the school.

I. Instructional Management

The primary purpose of the system is the direct management of the student's learning path leading to mastery of basic school objectives. The system began operation with a computer and remote terminal in October 1970. A preliminary and somewhat primitive version of the program was conducted on a manual basis during the 1969-70 school year.

Approximately 250 eighth grade students are currently scheduled in the Center for Individually Prescribed Learning Activities at Conwell for a portion of their instructional time. The student's independent study during this time is coordinated with a number of other programs of individualized instruction throughout the school. In the Center these students receive instructions concerning their learning packet assignments by means of the remote terminal. All packets are stored in the Center and individual progress is guided and monitored by a center supervisor and an instructional aide.

Students usually concentrate first on high priority objectives which they have not yet mastered. When a student completes all basic minimum objectives the focus of his instruction may change to develop his ability to learn in diverse ways. For example, the auditory learner may be instructed via visual techniques or vice versa. Or, in other instances, a student's instructional program could be arranged to move well beyond the basic minimum level for some objectives.

The essential underlying philosophy of the system is to assure that the student has mastered all of the basic school requirements first by using instructional techniques which match his strengths. Later on, efforts are made to overcome his learning weaknesses and to enrich his instructional program.

There are other ways the system can be used to contribute to the educational process outside of the IP Center itself. The remote terminal might be used by teachers to request information from the student assessment files or the curriculum data bank. A teacher, for example, might ask for a student's assessment data in order to plan a more effective classroom program for that child. Similarly, the teacher might ask for the scores of all students who demonstrate certain characteristics in order to organize small group instruction, form a science club, etc. Furthermore, a teacher might ask for the titles of all learning packets in a particular area or having specified learning characteristics in order to develop a more effective classroom presentation. These applications are currently being developed.

The central core of the model is a systematic set of procedures which is organized and managed by computerized techniques. The emphasis on automated procedures may leave an impression of a mechanized and sterile learning environment. Our experience suggests the reverse is closer to the truth. A continuous program of innovation and experimentation is maintained in the Center, testing ideas such as student tutoring, differential rewards for learning progress, etc. Structuring the purpose and direction of an educational experience seems to allow additional freedom for dynamic and imaginative educational practices.

II. Research and Evaluation

The overall CBIM System provides a structured model for organizing a portion of the educational process. Any of the individual elements of the model can be changed drastically without destroying the validity of the system itself. As data accumulates on student progress, the system facilitates evaluation of the measures, curricula, and matching rules in order to introduce changes on the basis of these results.

The main prerequisite for a research and evaluation effort is an active program of collection, updating, and retrieval of student performance data. A primary data source is the progress tests which are administered to each student as he completes each packet. These data can be used to examine the validity of the matching process.

No student will receive only packet assignments which are perfectly matched to his particular characteristics since the curriculum bank cannot provide many of the possible variations. Thus, a student designated as an auditory learner will receive some visual or kinesthetic materials. Do students show a higher percentage of success when presented with materials matched to their learner characteristics than when given similar packets not so matched? If not, the variable under consideration should be eliminated from the system unless some fault is found in either the measures or the curricular materials. Other variables which demonstrate research potential can be inserted at a later time.

The same question should be raised for each child at periodic intervals. The fact that a variable demonstrates validity across all students does not mean that the measured values will remain valid for each child. When a child is not showing improved performance with materials matched to his characteristics, his particular needs should be reexamined.

A more complex topic is the possible interaction of learner characteristics with the subject matter which is being learned. The system becomes more complicated (although not unmanageable) if it can be demonstrated, for example, that a child learns mathematics better with a concrete presentation and social studies with abstract materials. Evidence on this question will accumulate as the system is used.

Better guidelines for curriculum development would also result from the collection and analysis of operational data. The computer will accumulate data about the characteristics of packets which are frequently requested but not yet available. This information will be used to develop appropriate variations of existing packets.

In a larger sense, the system must prove its effectiveness as an instructional program which contributes to student learning. The question under evaluation at this level is whether children show improved performance in mastering basic objectives as a result of a program of structured independent study. A tentative answer to that question follows from a re-administration of the terminal measures which originally indicated the deficiencies after students have pursued a remedial instructional program.

Data from last year's operation (See Appendix B) indicate that a substantial percentage of children who showed deficiencies at the beginning of the school year were able to achieve mastery by the end of the school year. This growth might result from the independent learning program, progress in the regular instructional program, general maturation, or any combination of these factors. A more carefully controlled study would be needed to demonstrate cause and effect relationships. However, the fact is that positive change was made in the educational standing of these students. A computerized operation can efficiently maintain the data required to test the program's overall effectiveness and the hypothesized relationships of learner characteristics and packet assignments to student performance.

The system might also serve as a vehicle for a more formal research program. Gagné (1967) flatly states that "we do not know much more about individual differences in learning than we did thirty years ago." And Cronbach (1957, 1969) insists that the best way to adapt to individual differences is to reduce their effect by differentiated instructional techniques. According to Bracht (1969), however, research has provided very little evidence to help select the appropriate adaptations. Carroll (1967) talks of a massive and long range study of the problem of matching instructional method to individual difference variables. The system provides an opportunity to test many important research questions in a realistic educational setting.

III. Administrative Management

Every school expends a tremendous amount of clerical and professional time in the collection, maintenance, analysis, and reporting of administrative data in the areas of scheduling, attendance, inventory, and school population. A computerized system creates the potential for more efficient and effective performance of many of these school functions.

Some school management activities of this nature were programmed at Conwell as adjuncts to the instructional management system. Modular scheduling and flexible grade reporting are currently performed by computer. (See Appendix C for a schematic representation of the interaction between the various systems developed in this project.) Some aspects of these functions may be conducted through the remote terminal during the coming year. These activities cannot be detailed in this paper but the apparent potential of the computer in school administration is quite far-reaching.

IMPLICATIONS FOR DISSEMINATION

In what sense does this program promote a cooperative educational system with potential for use in other schools? When the model is completed and available for dissemination, what benefits might a school expect and at what cost? The Conwell experience suggests some tentative answers.

The number of children served is an important factor in calculating costs. At Conwell, each student is scheduled into the Center for two fifty-minute modules per week, resulting in approximately 20 students working in the Center at all times. Exactly how many students might be accomodated in a learning center of this type is not clear at this point. The number of students presently served is dictated by the limitations of space and materials. It seems likely that larger groups could be handled in a fully operational program and the cost of providing instructional services thereby reduced.

A fundamental assumption in disseminating the model is that many schools would benefit from an instructional program which supplements regular classroom instruction with a structured program of independent study. The instructional process which will be offered to other schools includes a package of materials and a process for organizing a program of individualized instruction. The package will consist of curriculum packets, tests, tape recordings, rating scales, computer programs, etc.

Each school's faculty can review the objectives, measures, curriculum packets, and computer programs prepared at Conwell with reference to use in their own situation. Selecting materials from this package, however, will not by itself result in a truly meaningful instructional program. Each school must be prepared to follow a series of steps which commit the administration, the teachers, and the students to an active tailoring of the program to the unique needs and conditions of the particular school situation. Basically, each school must analyze precisely what it is trying to accomplish, using the materials developed in the project as a guide.

The adaptation process calls for an extensive program of staff training and development. Teachers and administrators should begin by analyzing each of the Conwell objectives with reference to their own aims. Some of these objectives may prove appropriate in the new school situation; some will need to be revised; still others will be dropped and new ones added. The measures and curriculum packets must be studied in the same way for possible changes and additions.

Above all, the school must be prepared to make an active and long range commitment to further development of the program. Each participating school contributes new objectives, measures, and packets to a central bank as these are developed in the local school setting. In turn, each school draws from the bank according to its individual interests. The terminals provide the machinery for operating the system as well as the vehicle for collecting and disseminating new techniques.

The central bank serves as a coordinating and disseminating agency with the primary function of controlling the quality of the materials and researching their effectiveness. The participating members might select a committee to review all objectives, measures, and packets submitted to the bank. Only appropriately formatted materials which meet a designated level of quality would be disseminated through the system. The system would be monitored by a continuous program of research and evaluation.

DIRECTIONS FOR THE FUTURE

In the not too distant future, various programs of individualized instruction will become available for widespread use in schools throughout the country. Individually Prescribed Instruction (IPI) and a Program for Learning in Accordance with Needs (Project PLAN), are two examples of extensive educational programs which are currently under development. Edling (1970) has identified over 600 other programs of individualized instruction which may prove useful for some schools.

Each school must decide which of these approaches, if any, is related to their particular needs and objectives. No single approach, however, is likely to serve the best interests of all schools simply because there is a wide diversity of needs and objectives in American education. The present project is one effort to accommodate to this diversity.

Some modifications and improvements in the prototype are needed before the system is presented as an alternative to other programs of individualized instructions. The list of objectives is not a fully accurate and complete statement of basic and minimum school standards, even for Conwell School. The psychometric quality of many instruments has not yet been determined. The curriculum bank needs to be extended and more packet variations written. The operational procedures for student evaluation and instruction in the IP Center are inefficient. It seems fairly clear at this point, however, that the model can be changed to overcome these difficulties if sufficient resources are made available.

A final evaluation of the present model as an approach to the individualization of instruction raises more fundamental considerations for the future. Perhaps the major strength of the system is the effort to adapt instruction to fit the particular teaching objectives of each school and the individual learning characteristics of each student. Is the prototype flexible enough to adjust to the unique characteristics of many different kinds of schools? Can instruction be effectively adapted to individual differences in students? A viable program of truly individualized instruction must face these issues.

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FOOTNOTES

1. The six systems described and critiqued are: Systems Development Corporation - IMS; Pittsburgh Research and Development Center IPI/MIS; American Institutes for Research: Project 'PLAN'; Allen Kelley's (TIPS); University of Wisconsin (CMS); Instructional Management Aspects of the Stanford CAI Project.

2. The use of an aptitude measure is currently being reconsidered for two reasons. First, these tests appear to measure abilities which are highly correlated with those measured by reading tests and cognitive style tests. Second, it is proving difficult to write equivalent curricula materials which are appropriate for different aptitude levels.

3. These 72 variations would be reduced to 36 if "aptitude level" and its curriculum counterpart "difficulty level" were eliminated from the model.

APPENDICES

SAMPLE OF INTERACTIVE LANGUAGE

```
COMPUTER:
     PLEASE TYPE YOUR FIRST NAME, SPACE, AND LAST NAME

SUPERVISOR:
     0892
        A

COMPUTER:
     WHAT WOULD YOU LIKE TO DO?
     1  POST PROGRESS TEST
     2  START OBJ./ACT./INACT.
     3  DISPLAY
     4  FILE CHANGE

SUPERVISOR:
     3

COMPUTER:
     SELECT ONE, ENTER IT BY NUMBER
     1  DISPLAY STUDENT FILE INFORMATION
     2  DISPLAY CURRICULUM INFORMATION

SUPERVISOR:
     1

COMPUTER:
     SELECT ONE, ENTER BY NUMBER
     1  STUDENT PACKET HISTORY
     2  STUDENT SCHEDULE
     3  ACTIVE PACKETS

SUPERVISOR:
     1
```

COMPUTER:
PLEASE ENTER OBJECTIVE, OR OBJECTIVE/SEGMENT, OR OBJECTIVE/SEGMENT/PACKET HISTORY

SUPERVISOR:
1008

COMPUTER:

PACKET NUMBER	ACTIVE	START DATE	PACKET COMPLETE	SEGMENT COMPLETE	DIAG-NOSTIC	PROGRESS	ALT	PACKET RDLC	STUDENT RDLC
1008010001	NO	11/05/70	YES	YES	FAIL	PASS	NO	0131	2110
1008010002	NO	00/00/70	NO	YES	FAIL	NO INFO	YES	0131	2110
1008020003	NO	11/10/70	YES	YES	FAIL	PASS	NO	0131	2110
1008030004	NO	00/00/70	NO	NO	PASS	NO INFO	NO	1131	2110
1008030005	NO	00/00/70	NO	NO	PASS	NO INFO	NO	1101	2110
1008040006	NO	00/00/70	NO	YES	FAIL	NO INFO	NO	0131	2100
1008040007	NO	00/00/70	YES	YES	FAIL	PASS	NO	2110	2100
1008050008	YES	11/14/70	NO	NO	FAIL	NO INFO	NO	1110	2100
1008050009	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	0131	2100
1008060010	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	1121	2100
1008060011	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	0010	2100
1008070012	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	1131	2100
1008070013	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	2101	2100
1008080014	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	0131	2100
1008080015	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	1111	2100
1008090016	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	2121	2100
1008090017	NO	00/00/70	NO	NO	FAIL	NO INFO	NO	1101	2100

PLEASE TYPE YOUR FIRST NAME, SPACE, AND LAST NAME

	A	B	C*	D
OBJECTIVE	NO. OF STUDENTS FAILING JUNE 1969	NO. OF STUDENTS FAILING JUNE 1970	NO. OF STUDENTS REMEDIATING DEFICIENCY	% OF STUDENTS REMEDIATING DEFICIENCY
SPELLING	55	44	11	20%
GRAMMAR	81	48	33	41%
SENTENCE-FRAGMENTS	17	9	8	41%
SUBJECT-PREDICATE	52	26	26	50%
SINGULAR PLURAL	22	10	12	54%
SENTENCE-TYPE	44	24	20	45%
CAPITAL-IZATION	80	28	52	65%
PARTS OF SPEECH	73	45	28	38%

* NOT ALL STUDENTS HAD TIME TO WORK ON ALL OF THEIR DEFICIENCIES. HAD MORE TIME BEEN AVAILABLE, THE NUMBER OF STUDENTS REMEDIATING DEFICIENCIES MAY HAVE BEEN CONSIDERABLY HIGHER.

COMMUNICATION ARTS

	A	B	C	D
OBJECTIVE	NO. OF STUDENTS FAILING JUNE 1969	NO. OF STUDENTS FAILING JUNE 1970	NO. OF STUDENTS REMEDIATING DEFICIENCY	% OF STUDENTS REMEDIATING DEFICIENCY
ARITHMETIC SKILLS	53	12	41	77%
FRACTIONS	67	47	20	30%
PERCENTAGE	70	51	19	27%
TIME	42	20	22	52%
MAKING CHANGE	34	11	23	68%
BEST BUY	35	14	21	60%
CHART READING	48	23	25	52%
MEASURING	40	13	27	67%

MATHEMATICS

SEPTEMBER 1970

OBJECTIVE	A NO. OF STUDENTS FAILING JUNE 1969	B NO. OF STUDENTS FAILING JUNE 1970	C NO. OF STUDENTS REMEDIATING DEFICIENCY	D % OF STUDENTS REMEDIATING DEFICIENCY
LIVING THINGS	81	62	19	23%
PLANTS	91	71	20	21%
ANIMALS	61	42	19	31%
THE EARTH	54	32	22	41%
AIR & WEATHER	17	11	6	35%
SOLAR SYSTEM	4	4	0	0%
MATTER	7	5	2	28%
ATOMIC ENERGY	26	13	13	50%
LIGHT & HEAT	29	17	12	41%
MAGNETISM & ELECTRICITY	20	9	11	55%
SOUND	33	19	14	42%

SCIENCE

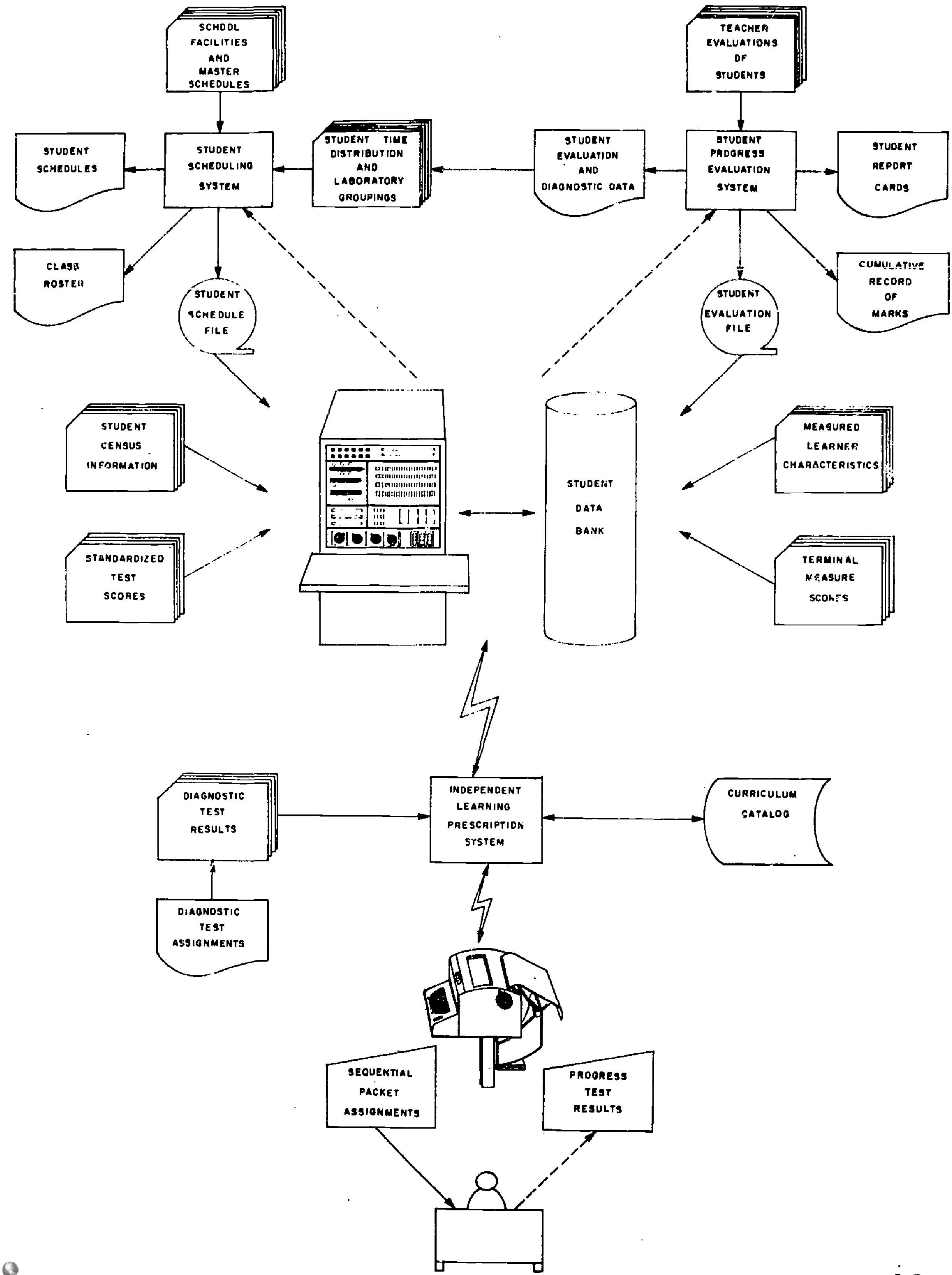
SEPTEMBER 1970

OBJECTIVE	A NO. OF STUDENTS FAILING JUNE 1969	B NO. OF STUDENTS FAILING JUNE 1970	C NO. OF STUDENTS REMEDIATING DEFICIENCY	D % OF STUDENTS REMEDIATING DEFICIENCY
MAPPING	41	15	26	63%
WHERE I LIVE	47	23	24	51%
WHO OUR NEIGHBORS ARE	36	19	17	47%
GEOGRAPHICAL CONCEPTS	46	29	17	37%
BASIC NEEDS	43	30	13	30%
ORIGIN AND GROWTH OF OUR NATION	47	32	15	32%
GOVERNMENT	49	36	13	26%

SOCIAL STUDIES

CONWELL INDIVIDUALIZED INSTRUCTION PROJECT

COMPUTER MANAGEMENT SYSTEM



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