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ANALYSIS OF INSTRUCTIONAL SYSTEMS. REPORT OF A PROJECT, NEW SOLUTIONS TO IMPLEMENTING INSTRUCTIONAL MEDIA THROUGH ANALYSIS AND SIMULATION OF SCHOOL ORGANIZATION. FINAL REPORT.

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REPORT NUMBER NDEA-VIIA-1130-20   PUB DATE   66
REPORT NUMBER BR-5-0738-20
REPORT NUMBER TM-1493-201-00
GRANT OEG-7-14-9120-217
EDRS PRICE MF-$0.45 HC-$10.88   272P.

DESCRIPTORS- *MODELS, *SYSTEMS ANALYSIS, INNOVATION, SECONDARY EDUCATION, INSTRUCTIONAL PROGRAMS, *SCHOOL ORGANIZATION, *COMPUTER ORIENTED PROGRAMS, *INSTRUCTIONAL INNOVATION, *ORGANIZATIONAL CHANGE, SIMULATION, HIGH SCHOOLS, EDSIM, SANTA MONICA, CALIFORNIA

THE USES OF SYSTEMS ANALYSIS AND COMPUTER SIMULATION OF SCHOOL ORGANIZATION WERE EXPLORED TO FIND NEW WAYS TO IMPLEMENT INSTRUCTIONAL MEDIA. THE USES OF SYSTEMS ANALYSIS RECOMMENDED WERE--(1) TO FACILITATE IMPROVEMENT OF PRESENT INSTRUCTIONAL AND EDUCATIONAL PLANNING SYSTEMS AND (2) TO EXPLORE THE FEASIBILITY OF PROPOSED SCHOOL ORGANIZATIONS. THE RECOMMENDED PROCEDURES FOR USE OF SYSTEMS ANALYSIS WERE--(1) DEFINE THE MAJOR OVERALL PROBLEM TO BE SOLVED, (2) MODEL THE SYSTEM, AND (3) USE THE MODEL TO STUDY THE EFFECTS OF CHANGES OF THE SYSTEM. A TECHNIQUE CALLED "EDSIM" WAS DEVELOPED AS PART OF THE PROJECT TO MODEL A SYSTEM BY MEANS OF A COMPUTER PROGRAM. FOLLOWING 11 ANALYSES OF SCHOOL ORGANIZATIONS, IT WAS CONCLUDED THAT ALTERING SCHOOL ORGANIZATIONS TO ACCOMMODATE INDIVIDUAL DIFFERENCES OF STUDENTS REQUIRES (1) ADEQUATE SELF-STUDY INSTRUCTIONAL MATERIALS, AND (2) ADEQUATE SYSTEMS TO PROVIDE INFORMATION TO INSTRUCTORS, COUNSELORS, AND ADMINISTRATORS ABOUT THE STATUS OF INDIVIDUAL STUDENTS. TO MEET THESE NEEDS, THE INVESTIGATORS RECOMMENDED (1) CONTINUED DEVELOPMENT OF THE COMPUTER-BASED SYSTEM TO ASSIST STUDENTS AND COUNSELORS IN PLANNING, (2) CONTINUED STUDY OF THE USE OF INFORMATION PROCESSING FOR STUDENT INSTRUCTION, (3) INSERVICE TRAINING OF SELECTED SCHOOL PERSONNEL IN THE PREPARATION OF INDIVIDUALIZED COURSE MATERIALS, AND (4) DEVELOPMENT OF PROCEDURES FOR THE MANAGEMENT OF CHANGES IN SCHOOLS. (AL)

TM-1493/201/00

Final Report

Analysis of Instructional Systems

19 April 1966

TM-1493/201/00

TECHNICAL MEMORANDUM

(TM Series)

The research reported herein was conducted under SDC's independent research program and Grant 7-14-9120-217, U. S. Department of Health, Education, and Welfare, Office of Education.

Final Report

Analysis of Instructional Systems

Report of a Project
New Solutions to Implementing Instructional Media Through Analysis and Simulation of School Organization

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Title VII of P.L. 85-864
National Defense Education Act of 1958
Grant 7-14-9120-217

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A-2348 4/65

ABSTRACT

This is the final report of a project designed to explore uses of system analysis and computer simulation in studying innovation in public secondary schools. The project, entitled New Solutions to Implementing Instructional Media Through Analysis and Simulation of School Organization, was jointly sponsored by the U. S. Office of Education and System Development Corporation. The major findings reported include the identification of two ways for using system analysis in education, the specification of procedures for conducting analyses of instructional systems, and implications for school organization. These findings resulted from the employment of system analysis methods in 11 studies at six selected secondary schools. The uses found for system analysis are: (1) to facilitate improvement of present instructional and educational planning systems, and (2) to explore the feasibility of proposed school organizations. The recommended procedures for system analysis involve three steps: (1) defining the major overall problem to be solved by the system; (2) modeling the system; and (3) drawing implications from the model relative to the purposes for the system. Modeling a system by means of a computer program (EDSIM), a technique that was developed as part of the project, provides an analyst with a model that is both explicit and manipulatable. The implications of the 11 analyses for school organization can be summarized as follows:

Although there is a definite trend in secondary education to search out and introduce ways to alter school organizations so that the individual differences among students can be accommodated, no school has yet evolved an organization to successfully meet this objective. Schools striving in this direction are presently blocked because they lack two major resources: (1) adequate self-study instructional materials, and (2) adequate systems to provide information to instructors, counselors, and administrators about the status of students as individuals. Recommendations for attacking these problems, growing out of the study include: (1) continued development of the computer-based system to assist students and counselors in academic planning that was started in the project; (2) continued study of the use of information processing in the classroom to design systems that will collect, store, and display student information so that it can be used in the immediate instructional process; (3) in-service training of influential school personnel in the skills of designing individualized course materials; and (4) development and dissemination of procedures for the management of changes in schools.

PREFACE AND ACKNOWLEDGMENTS

The work described in this report was accomplished during a two and one-half year period from June 28, 1963 to January 31, 1966. During this time a national survey of innovating secondary schools was conducted; a general computer simulation capability (EDSIM) was developed for constructing models of instructional systems; system analyses were performed at six secondary schools; and automated procedures were developed for conducting an educational planning interview.

Presenting the results of this large amount of work in a format that is considerate of the time and patience of most readers was a formidable problem. The solution was to provide a general discussion of the study as the main body of this report in Chapters I through V, and to place the detailed description of work in eight appendixes. Consequently, the reader can obtain an understanding of the problems (Chapter I), the procedures (Chapter II), the general results (Chapter III), the conclusions (Chapter IV), and the recommendations for further study (Chapter V) in the first part of the report. The additional material presented in the appendixes is divided into sections as follows: Appendix A includes results of the survey of innovating schools. Appendix B is a description of the simulation capability. Appendixes C through G are reports of the system analysis studies conducted at five innovating schools. Appendix H is a report of a special counseling study conducted at a sixth school. These appendixes summarize the work reported in the Tech Memos (working documents) that are listed in the annotated bibliography presented at the rear of this report.

We wish to express our appreciation to all of the schools that participated in this study, and particularly to those that participated directly in the system analysis studies. The participating schools and school organizations were Brigham Young University Laboratory School, Provo, Utha; Nova High School, Ft. Lauderdale, Florida; Theodore High School, Theodore, Alabama; Buena Vista High School, Saginaw, Michigan; Garber High School, Essexville, Michigan; and the Palo Alto School District, Palo Alto, California.

These six schools were selected because they are in the forefront of educational innovation. Objectivity and a complete absence of defensiveness or guardedness on the part of the staff and students were outstanding characteristics in each of these schools. It is only in this kind of social environment that real problems and alternative solutions can be freely defined.

Without the contribution of time and support from a number of people from these schools this study would have been impossible. Among them a few names stand out as those who gave a great deal of their time. They were as follows:

Dr. Edwin Read,* Mr. Lowell Thomson, Mr. Wallace Allred, and Mrs. June Whiteford of Brigham Young University Laboratory School; Mr. Arthur Wolfe and Dr. Donald Schneider of Nova High School; Mr. John Jackson and Mr. Carl Knotts of Theodore High School; Mr. Joseph G. Barr, Mr. Robert Blue and Mr. James Tuck of Buena Vista High School; Mr. Charles Josephson and Mr. Quintin Cramer of Garber High School; and Mr. William Hutchinson, Miss Barbara Peterson, and Dr. Murray Toudow of the Palo Alto School District.

Appreciation is also tendered to Dr. John W. Loughary of the School of Education of the University of Oregon and to his students, Robert Hurst and Deloss Friesen** for their work on the Palo Alto counseling study. Dr. Loughary served as a consultant to the project and Hurst and Friesen developed doctoral studies that contributed substantially to the research effort. Gratitude is also expressed to John Coulson, Lee Gorsuch, Ralph Melaragno, Gerald Newmark, Harry Silberman, our colleagues at System Development Corporation, who contributed consultation and assistance to the project.

Finally, appreciation is expressed to Mrs. Lila Kabana for her excellent skill in facilitating the extensive documentation required for this project.

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CHAPTER I. STATEMENT OF THE PROBLEM

When this study was proposed in 1963, American education appeared to be on the brink of a radical departure from tradition. The development of a new technology that appeared to have great potential for educational improvement made it necessary to consider alternatives to our traditional ways of organizing for instruction. One major outcome of the new technology appeared to be that the educational system could better adapt itself to individual differences among students. The lockstep system of education was challenged by the advent of self-instructional materials that would permit students to progress through courses at their own rate, and by the development of computer-based instructional systems that would respond differentially to students. In addition, use of teachers working together in teams, use of mass media for large group instruction, and development of computer programs to assist in the construction of master schedules also challenged the older systems. The traditional procedure of having 20 to 35 students spend the same amount of time together each day with one teacher, all progressing through the same set of materials at the same rate, seemed inconsistent with the developments taking place in instructional technology.

Organizational changes seemed inevitable under the new systems. The advent of new media into the classroom would probably reduce the importance of the teacher's role as a presenter of information, because students could work on self-instructional materials without having the teacher as the center of attention.

In addition to changes in the roles of personnel and in the organization of students, teachers, and materials, new physical arrangement of space appeared necessary. There would be a need for individual study booths or carrels if students spent a greater portion of their time working individually. If teachers worked more frequently in small groups or with students individually, teaching spaces suitable to the size of the group might be needed.

By the same token, new instructional media and changes in organizational structure could seriously alter the kinds of interactions that students would have with other students and with teachers. For example, one result of a school system breaking away from the lockstep procedure would be that students would spend less total time as a group in the presence of the teacher, but more time in individual contacts with teachers and in small group meetings.

Changes in the way in which students progress through the schools would also have effects on the way in which students would graduate from the schools. For example, a school that permitted students to work a large portion of the time in an individual mode and to progress at their own rate through the curriculum would graduate its students on an individual basis rather than in large groups or "graduating classes." The consequence of this kind of change could be tremendous, since it would markedly alter the entry dates into educational institutions that the students would attend later. Changes in the organizational structure would also cause changes to the information processing requirements. For example, if students were permitted to work at their own rate on an individual basis, the teachers would have much less information about what students were doing. Each student would probably be at a different point in the same course at any given time and would be ready for different activities at different times. Therefore, the problem of scheduling resources for activities would become exceedingly complex. And finally, the problem of scheduling the teacher's time for working with individual students could be most difficult.

It was these conditions in 1963, of a new and rapidly expanding development in educational media and technology, and of an apparent associated revolution in organizational innovation, that created the need for this study. An analogy was seen between organizational problems faced by schools and organizational problems in military and industrial situations where solutions have been sought through system analysis techniques.

System analysis procedures that feature the construction of simplified computer models of the organization being studied provide a means for a school to come to grips with the problem of changing its organization. Use of such techniques can lead to a delimitation of a problem so that it is no longer vague and frustrating. To a great extent the primary product of an analysis is to determine the purpose for a system and to make this purpose explicit. For example, the stated purposes for a particular way of organizing instruction (e.g., team teaching) are usually so vague that virtually any solution is acceptable. Modeling a system gives it a structure so that it can be examined objectively and its implicit objectives or purposes can be made explicit. In education, for example, the model of a particular course may show that selection of a topic for presentation on a particular day is a function of the day of the week. When this is made clear to school officials, they may want to consider alternative strategies in the selection of course substance. For example, they may wish to base selection on the needs of students.

A. OBJECTIVES OF THE STUDY

It was the purpose of this study to attain the following objectives:

1. To develop procedures for the system analysis and computer simulation of educational systems.

2. To use system analysis procedures empirically in studies at five innovating secondary schools for the general purpose of planning organizational change in the schools and for the specific purpose of defining uses for system analysis.

3. To draw conclusions from the results of the above system analyses about the problems faced by education in general as attempts are made to organize instruction to be more sensitive to the individual needs of students.

4. To examine the results of each of the analyses performed for their implications bearing on the following:

   - New roles for personnel.
   - Effects of using new media on pupil/pupil and teacher/pupil interaction.
   - New uses for data processing.
   - Arrangement and use of space.
   - Estimates of the effects of innovation on the characteristics of graduates.

B. SPECIAL COUNSELING STUDY

After this project was underway, the authors saw an opportunity to relate to it a counseling study that had been contemplated for some time. This new study, while not focused on the same educational purposes as the original project, did involve the use of system analysis, so approval was obtained from the Office of Education to append it to the work as originally planned.

This special study dealt with the counseling function in secondary schools, and involved the use of system analysis procedures and the construction of a computer program model of a counselor's behavior in an educational planning interview. The objectives for this special study as it relates to the present project are subsumed under the first objective stated in Section A, above. The rationale for the study as an independent piece of work and its own particular objectives are included in a complete description of the study contained in Appendix H.

CHAPTER II. PROCEDURES

This study was conducted in two stages. In the first stage a survey was made of innovating secondary schools, five of which were selected for further study. In the second stage an intensive analysis was made at each of the five selected schools.

A. PROCEDURES FOR SELECTING SCHOOLS FOR ANALYSIS

1. Conduct of Survey

Names of schools that were involved in innovation were obtained from two sources. Letters (Appendix A, Attachment 1) were sent to each of the 50 state departments of education during July 1963. These letters requested the names of any schools in their states that were actively engaged in innovations. Innovations were described in the letters as including the use of television, language laboratories, programmed instruction, team teaching, etc. The content and structure of the curriculum were not mentioned as innovations in the letters, since the research was focused on the organizational problems associated with the use of educational media.

Letters requesting names of innovating schools were also sent to the following leaders in education who were known to be interested in innovative schools: J. Lloyd Trump, Thomas Clemens, Jack Edling, Lloyd Morrisett, Lester Nelson, Seth Spaulding, and Wilbur Schramm.

A list of 200 schools was obtained from these sources. The schools, listed by states, are shown in Appendix A, Attachment 2.

Questionnaires (Appendix A, Attachment 3) were sent to each of the 200 schools asking them for detailed description of their current and their planned innovations. The schools were asked to provide detailed descriptions of the innovations and to list the courses in which the innovations were being applied, the grade level of the courses, and the number of months that the innovation had been in use. Information was collected about the following innovations: programmed learning using teaching machines; programmed learning without teaching machines; educational television; closed-circuit television; language laboratory; flexible scheduling; ungraded programs; team teaching; and the continuous progress plan.* Information was also requested on the use or plan

*The continuous progress plan is an instructional plan for teaching in an individualized mode. The name was given by educational researchers at Brigham Young University Laboratory School (see Reference 24 and Appendix C).

to use data processing equipment for any of the following functions: attendance accounting; grade reporting; test scoring and analysis; schedule preparation; and courses for students in data processing.

Eighty-nine schools returned the questionnaires. All of the returns were received before January 31, 1964. The questionnaires were analyzed and the responses tabulated so that the schools most extensively and intensively involved in innovation could be identified. The results of this analysis are presented in detail in Appendix A.

Twenty-five percent of the schools were selected to be visited. The 22 schools selected were identified as those that appeared to be most intensively involved in innovation. Schools were included in the list for site visits either if they were using a single innovation (e.g., programmed learning) in many classes, or if they were using a number of different innovations.

The 22 schools selected from the survey were:

Arlington County Schools and Wakefield High School,
Arlington County, Virginia
Brian McMahon High School, Norwalk, Connecticut
Brigham Young University Laboratory School, Provo, Utah
Buena Vista High School, Saginaw, Michigan
Bunnel High School, Stratford, Connecticut
Centennial Joint School System, Johnsville, Pennsylvania
Concord-Carlisle High School, Concord, Massachusetts
Easton Area Joint High School, Easton, Pennsylvania
Evanston High School, Evanston, Illinois
Flowing Wells High School, Tucson, Arizona
New Trier High School, Winnetka, Illinois
Newton High School, Newton, Massachusetts
Nova High School, Ft. Lauderdale, Florida
Patrick Henry High School, Roanoke, Virginia
Ridgewood High School, Ridgewood, Illinois
River Forest High School, Oak Park, Illinois
Theodore High School, Theodore, Alabama
Washington County High School, Hagerstown, Maryland
Wassau High School, Wassau, Michigan
Wayland High School, Wayland, Massachusetts
Weston High School, Weston, Massachusetts
Wisconsin Heights High School, Blackearth, Wisconsin

Each of the 22 sites listed was visited by a member of the research staff. Four other schools were added to the list for field site visits at the recommendation of System Development Corporation personnel who were conducting the traveling seminar in education.* The schools were:

Cold Springs Harbor High School, Long Island, New York
Flint High School, Flint, Michigan
Manhasset Public Schools, Long Island, New York
Washington Counties High School, Hagerstown, Maryland

Twenty-six schools were visited. Project personnel used the guidelines outlined in Appendix A, Attachment 4, for making arrangements with and collecting data from the schools.

2. Selection of Schools

When all of the field site visits and reports were completed, the project staff selected the schools for the system analysis studies. Actually, one school, Brigham Young University Laboratory School, was selected before the survey was completed. This early selection permitted the system analysis effort to be started and made data available for beginning development of the computer simulation capability. (Brigham Young University Laboratory School was selected because it was the only school known to the project staff at that time that was attempting to adapt instruction to the individual student.)

After Brigham Young University Laboratory School was chosen, three additional schools were selected on the basis of the survey data: Theodore High School, Theodore, Alabama; Nova High School, Ft. Lauderdale, Florida; and Buena Vista High School, Saginaw, Michigan. The fifth school, Garber High School, Essexville, Michigan, was not selected until the last year of the study. Selection of the fifth school was postponed to allow for subsequent information about innovating schools that might have been overlooked in the survey.

Any of the 26 schools visited by project personnel would have provided an interesting subject for system analysis. The five schools that were finally selected were chosen because of their extensive involvement in innovations that included use of media and modification of the procedures for organizing instruction. Theodore High School was selected because it was attempting to adapt instruction to individual differences in many different courses. School personnel had developed procedures very similar to those developed at Brigham Young University Laboratory School, even though there had been no communication between the two schools.

*In May 1964 System Development Corporation conducted a traveling seminar in which 120 educators viewed outstanding examples of innovation. The work included a follow-up study one year later to assess the effects of the seminar. The project is reported in SDC document TM-2691 dated October 25, 1965.

Nova High School was selected because it had clearly gone further in its attempts to innovate than any other school we could find. The innovations included a new modern secondary school with well equipped learning resource laboratories in every building, a closed-circuit television system with a television monitor in every classroom and individual monitors in the learning resource laboratory study carrels, an overhead projector in every classroom, a Chester Dialog audio tape system, etc. In addition, the school was planning to combine team teaching with individualized instruction.

The Buena Vista High School was selected because it was using a combination of team teaching and a well-implemented closed-circuit television system.

Garber High School, the fifth school, was selected in the last year of the project. The school was recommended by members of the Buena Vista High School staff. It was included in the study because the school staff had developed and was implementing modified individualization in instruction involving small groups. The plan represented an interesting compromise between the completely individualized and the usual lockstep group procedure.

B. DEVELOPMENT OF SYSTEM ANALYSIS PROCEDURES

Since the purpose of doing system analyses at the five schools listed above was to explore and define analytic procedures, it was to be expected that an analysis at a particular school would not necessarily employ the same procedures as those used in other contexts. Consequently, project personnel did not treat all analyses in the same way. For example, as mentioned in Section A, above, the work at Brigham Young University Laboratory School was started quite early in the project. This work was defined initially as a system analysis of the total school and resulted in a detailed descriptive model of designs for an improved system. A second analysis conducted later at Brigham Young University Laboratory School focused on the instructional system used in the ninth-grade algebra course and made use of a computer model of the course.

At Nova High School, Theodore High School, Buena Vista High School, and Garber High School, school officials were asked to designate a course or department that exemplified their particular use of media for instruction. These designated courses or departments became the focus for the system analyses conducted at these four schools. In approaching these schools, the project followed a set of general procedures involving three tasks.

- Definition of the Area of Interest
- Definition of the System
    - by verbal description model
    - by computer simulation model
- Analysis of the Modeling Results

The specific activities that were involved in these steps are described below:

1. Definition of the Area of Interest

In the first step, the area of interest to be analyzed was defined and a single system for intensive analysis was selected.

The area of interest was defined by collecting data about the general characteristics of the school environment, such as the size of the student body, the number of teachers, the kind of innovations that the school was trying to develop, and a general description of procedures that had been implemented to date. These data were collected by interviewing school administrators and members of the teaching staff and by observing some of the innovations in process.

Since the innovations were being implemented in specific courses or in specific departments, a single course or department was selected as the focal system for intensive analysis. The following courses or departments were chosen at the five schools:

School	Program Studied
Brigham Young University Laboratory School	Ninth-grade algebra
Theodore High School	10th-grade biology
Garber High School	7th- through 12th-year mathematics
Nova High School	10th-grade social studies
Buena Vista High School	11th-grade English

2. Definition of the System

The instructional system was defined in three steps: (a) detailed data were collected about the procedures used in the focal system; (b) a document was produced that described the operation of the focal system; and (c) computer simulation models of the focal system, and/or experimental changes to the system model, were made.

a. Collection of Focal System Data

Data were collected that provided a detailed definition of the selected school organization as an instructional system. Specific information was gathered about the following: the sequence of activities that students go through in the organization; the resources and procedures used for conducting activities; the decisions that were made regarding the rules for processing students; the information used for decision making; and the characteristics of the students.

b. Production of the System Description Documents

Documents were written which defined the instructional process as a system for processing students. The sequence of activities was described by flow diagrams that showed the alternative pathways that students could traverse through the system. After the focal system had been defined, it was then studied further through computer simulation.

c. Construction of Computer Simulation Models

A set of general procedures for constructing computer simulation models of instructional systems was developed. Models were constructed in three steps: (1) formulating the problem to be modeled; (2) programming the model for the computer; and (3) running the program on the computer to generate data.

(1) Formulating the Problem to be Modeled

Models were formulated for computer simulation to represent the operation of the course as it was defined in the system description document. To formulate the models so that they could be simulated by a computer, the analyst prepared a flow diagram showing the interrelationships among the activities in the model. In addition, he identified the decision rules that governed the selection of an activity by a student, the time that each activity would last, and the basis on which the next activity in the sequence would be selected. The selection of activities depended upon the characteristics of the individual students, the history of previous activities that students had gone through, random selection, or a combination of any of these. Specifically, the following characteristics of the system to be simulated were defined:

- Definition of a population of students that may vary in size. For most of the models that were developed in the project, 100 students were simulated for each course.
- Descriptions of classes of students. Students can be characterized as individuals by defining them as members of a descriptive class. A number of the models that were developed characterized students as belonging to one of three classes--fast, medium, and slow. These classes were related to the rate of progress of the student.
- Definition of activities. An activity is a specific task defined by the analysis and is represented by a programming subroutine in the model. As many as 60 activities can be defined for any one model. Each of these activities can be assigned a label definition for the type of task which it represents.

- The length of time that students spend in activities and in courses.

- Which activity will be selected next in a sequence for an individual student or groups of students, based upon probabilities that are associated with different classes of students. For example, slow students can be given a high probability that they will need frequent help from the teacher. Likewise, students may take more than one course; one model simulated 100 students taking five different courses. Another model simulated six different groups of students going through six years of course work in mathematics.

- The names of activities, their length of duration, their sequence and the rules for sequencing different kinds of students (by means of input cards).

(2) Programming a Model for the Computer

The models were constructed using EDSIM.* EDSIM is written in the JOVIAL programming language for the Philco 2000 computer. Initially, the plan was to develop a general model that was an aggregation of specific programming subroutines. The subroutines were viewed as fixed representations of the unique instructional activities identified by the system analyses performed at each of the schools. The model of the Brigham Young University Laboratory School was to be developed and, when the Buena Vista model was needed, the additional programming subroutines to represent Buena Vista's unique activities would be added and integrated with the programs needed for the Brigham Young University Laboratory School model. It was anticipated that this general model would tend to become progressively larger as more and more schools were studied and their unique activities were added to the model. However, it was believed that eventually the aggregate model would contain a diversity of programming subroutines so that modeling any specific school would only be a matter of selecting the needed subroutines and voiding others.

As the programming task for the project progressed, the differences among schools was so great that this procedure proved impractical. It was found that the complexity of integrating new subroutines into the general model magnified the probability of errors in the

*The name EDSIM (educational simulation) was coined by project personnel to stand for the program system described in Appendix B.

program logic to an intolerable degree. In addition, the size of this general program necessitated increased computer memory storage and lengthened program running time to an extent that was undesirable.

Consequently, the procedure of adding specific subroutines to an aggregate model in order to represent a school was abandoned and a more flexible and economical system for modeling was developed. These procedures are defined in detail in Appendix B. In summary, the presently used logic provides a general definition for activities, and hence a general programming subroutine to represent any particular activity. The specific instructional activities identified in a particular school can be modeled with this general subroutine by specifying three aspects of the activity: (1) a numerical identity for the activity; (2) the rules that govern the selection of a subsequent activity by a given student; and (3) the rules that govern how long a given student will remain in the activity.

As the EDSIM program currently exists, a programmer-user must construct the models for the computer. However, with some additional work on EDSIM, it could be adapted to a time-sharing computer so that a person with no programming skill could construct a model by teletype communication with the computer. The user would communicate in conventional language and would receive conventional-language output on the teletype.

(3) Generation of Output Data

A detailed recording of each student's history in the course is made for each simulated model. Output summaries are produced by another set of programs that select and organize categories of data from the detailed recording. Some of the output summaries used are as follows:

- The total number of times a particular class of students passed through each activity in the model for any defined segment of time. For example, fast students went through individual study 82 times in the period between day 6 through 10.

- The total student time spent in an activity for any defined segment of time. For example, 168 students spent 840 time cycles (1/8 hour units) in group help in the period between day 4 and 20.

- Frequency distributions of the number of times that various events occur in the model. For example, five fast students were in group help twice, three fast students were in group help four times, etc.

- A complete history of any individual student's performance in the model.

C. USES OF THE SYSTEM ANALYSIS PROCEDURES

Nine separate system analyses were performed during this project. The specific procedures used in each of the analyses took their form and content from the purpose for each analysis. Seven of the systems were modeled on computer; the remaining two were described by a verbal model. Table I summarizes the nine system analyses by school, the particular system within the school that was selected for analysis, the purpose for the analysis, and the procedures that were used. The last column in Table I references the appendix where each analysis is described in detail.

D. PROCEDURES FOR THE SPECIAL COUNSELING STUDY

The procedures used in the special counseling study were specific to the unique purposes of that study. They are described in Appendix H. The special study procedures that relate to the overall project involve the three major tasks outlined in Section B, above. The data collection task included: (1) selecting a single counselor for the Palo Alto school system for intensive study; (2) recording his verbalizations as he analyzed the contents of 20 students' cumulative folders prior to interviews; and (3) recording each of the 20 interviews.

The second task involved formulation of two systems from the interview data, both of which resulted in computer programs. The first of these two systems accepts data from a student's cumulative records, analyzes these data using rules that simulate the counselor's behavior, and prints out summary statements about the student that represent the counselor's conclusions. A model of this system was programmed for the Philco 2000 computer. The second system consisted of a program for the Q-32 time-sharing system that controls a teletype in such a way that the teletype simulates the counselor's interview behavior by typing out information and questions to the students. The student responds by typing in his answers to the questions. The automated interview includes the following steps: review of the student's most recent grades, consideration of problems in any courses, exploration of educational and vocational goals, and preparation of the program of courses for high school.

An investigation was conducted between March 22 and March 26, 1965 to assess the simulation and to appraise student acceptance of the automated interview. Forty ninth-grade students were randomly selected from the population of ninth-grade students at the Wilbur Junior High School in Palo Alto, California. The students' total Scholastic and College Aptitude Test scores ranged from the third percentile to the ninety-sixth percentile. The group was somewhat above the national average in aptitude.

Table I. Summary of Procedures for Nine System Analyses

School	Subject for System Analysis	Purpose for Analysis	Procedures Used for Analysis	Reference
Brigham Young University Laboratory School	1. Total School	Design of ideal school using unlimited resources.	1. Conferences with educational experts in design of continuous progress school. 2. Production of verbal descriptive models for ideal school.	Appendix C
	2. Ninth-Grade Algebra Course	Definition of problems in organization of course.	1. Collection of data about procedures used in course. 2. Formulation of computer model of course. 3. Simulation of course operation. 4. Analysis of simulated data and comparison with actual course data. 5. Definition of problems.	Appendix C
	3. Autonomous Scheduling Procedures	Exploration of feasibility for proposed procedures.	1. Formulation of computer model of proposed procedures. 2. Simulation of model. 3. Analysis of simulated data. 4. Statements of conclusion drawn from results of simulation.	Appendix C
Nova High School	4. 10th-Grade Social Studies Course	Definition of problems in organization of course.	1. Collection of data about procedures used in course. 2. Formulation of computer model of course. 3. Simulation of course operation. 4. Analysis of simulated data and comparison with actual course data. 5. Definition of problems.	Appendix D

Table I. Summary of Procedures for Nine System Analyses (Cont)

School	Subject for System Analysis	Purpose for Analysis	Procedures Used for Analysis	Reference
Theodore High School	5. Biology Course	Definition of problems in organization of course.	1. Collection of data about procedures used in course and individual progress of students. 2. Formulation of computer model of course. 3. Simulation of course operation. 4. Analysis of simulated data and comparison with actual course data. 5. Definition of problems.	Appendix E
	6. Biology Course	Exploration of feasibility for proposed procedures.	1. Formulation of computer model of proposed procedures. 2. Simulation of new procedures. 3. Analysis of simulated data. 4. Statements of implications of results of simulation.	Appendix E
Buena Vista High School	7. 11th-Grade English Course	Definition of problems in organization of course.	1. Collection of data about procedures used in course. 2. Formulation of computer model of course. 3. Simulation of course operation. 4. Analysis of simulated data and comparison with actual course data. 5. Definition of problems.	Appendix F

Table I. Summary of Procedures for Nine System Analyses (Cont)

School	Subject for System Analysis	Purpose for Analysis	Procedures Used for Analysis	Reference
Buena Vista High School (Cont)	8. Total School	Design of ideal school that combines individual progress with closed-circuit television.	1. Conferences with school officials. 2. Production of verbal descriptive model for ideal school. 3. Discussion of problems of implementing design.	Appendix F
Garber High School	9. Mathematics Curriculum	Exploration of feasibility of plan.	1. Collection of data about procedures used in mathematics department. 2. Formulation of computer model of six-year plan. 3. Simulation of operation of plan. 4. Analysis of simulated data. 5. Statements of implications of results of simulation.	Appendix G

A teletype was installed at the school and was connected by telephone line to the Q-32 computer at SDC in Santa Monica. All 40 students took the automated interview. In addition, all of the data in the cumulative folders of the 40 students was analyzed by the appraisal program. Twenty of the 40 students were also interviewed by the original counselor; the remaining 20 were interviewed by a second counselor. The second counselor was included in the study to provide some estimate of the generality of the model.

To control the effects of sequence and order, each group of 20 was further divided into two subgroups of 10. One group of 10 students went to the computer first for the interview and then went to the counselor. The second group of 10 students saw the counselor first and then was interviewed by the computer.

Following each interview, either by human or machine, the students were given an opinion questionnaire designed to measure their attitudes toward the interview. When each student had completed both the human and the machine interviews, he was given a standardized interview to obtain more detailed information on his attitudes toward the machine and human interviews.

CHAPTER III. RESULTS OF THE STUDY

The results of the study are presented in three places. The results of the nine system analyses and the results of the special counseling study are presented in Sections A and B below. The results of the survey of innovating schools are presented in Appendix A.

A. RESULTS OF THE NINE SYSTEM ANALYSES

Detailed summaries of the nine system analyses listed in Table I are contained in Appendixes C through G. These summaries describe the work in relation to the five innovating schools. Each of the summaries include a general description of the school, a description of the problems that were studied, the results of the system analysis, and a discussion of the implications of the results for the five general problem areas: i.e., new roles for personnel; effects of using new media on pupil/pupil and teacher/pupil interaction; new uses for data processing; arrangement and use of space; and estimates of the effects of innovation on the characteristics of the graduates. Each of the nine system analyses represents studies that are unique in terms of the problems studied and results obtained; therefore they are reported as separate independent studies. The results of the nine studies are briefly summarized in Table II. In the first column, the schools and the subjects of the analyses are listed. The second column contains brief summaries of the major results. The third column refers the reader to the appropriate appendix and pages in the appendix where more complete discussions and data are provided.

B. SUMMARY OF RESULTS OF THE SPECIAL COUNSELING STUDY

The results are summarized in three broad areas: (1) those areas in which there appeared to be no marked difference between the counselor and the automated systems; (2) those areas where differences were observed between the automated systems and the counselor; and (3) findings on the reaction of students to the automated procedure.

1. Areas of no Difference Between Automated Systems and Counselors

No significant differences were found between the appraisal behavior of the two counselors and the computer appraisal programs on three-fourths of the appraisal statements. Both human and computer performed similarly in terms of identifying the following: changes in the pattern of student's grades, underachievement, overambitious plans, need for remedial work, and appropriate and inappropriate posthigh school plans.

Table II. Summary of the Major Results of the Nine System Analyses

Nine System Analysis Studies	Major Results	References
1. Brigham Young University Laboratory School Total School	1. An information processing center for a future continuous progress school was designed with the following functions: calculating of student expectancy scores; processing of registration data and scheduling of students, teachers, space, and equipment on a day-to-day basis; constructing summaries of student data for school staff planning; analyzing current and planned use of resources for planning resource needs; and tracking and monitoring of student performance.	Appendix C, pages 4-6.
	2. An Instructional Materials Center was designed which includes procedures for: acquisition and disposition of purchasable items; acquisition of new books and equipment; circulation of books; and scheduling the use of the facility.	Appendix C, pages 6,7.
2. Brigham Young University Laboratory School Algebra Course	1. Simulation of the progress of students through the continuous progress course shows that the variation among students in the amount of progress through the course will increase as time in the course increases. The distribution of student progress rapidly changes from an approximately normal distribution to a rectangular shape. The range of progress for slow students more than triples in six months. This steady increase in heterogeneity of student progress makes it difficult to schedule students into groups for remedial help. The trend is clearly toward increasing the number of groups and reducing the number of students in each group. This increase in the number of groups increases the demand on teacher time and tends to force students to wait longer for help.	Appendix C, pages 12-16. Figures 1, 2.

Table II. Summary of the Major Results of the Nine System Analyses (cont)

Nine System Analysis Studies	Major Results	References
2. Brigham Young University Laboratory School Algebra Course (cont)	2. Analysis of real course data showed that a significant portion of the variance in student rate of progress was accounted for by the combination of intelligence, homework, and STEP listening. Some evidence was presented that suggested that reading ability contributes to variance in progress for the slow students, but not for students in the fast and medium groups.	Appendix C, pages 16,17.
3. Brigham Young University Laboratory School Autonomous Scheduling Procedures	1. One hundred students were simulated as taking five courses on a continuous progress basis and as being free to schedule themselves for individual work on any course at any time they desired during a five-hour individual study period. If students needed to take a test or needed help, they filed a request and progressed to work on another course. All help and test requests were met at the end of the day after the individual study period. The data produced by the simulated model suggested the following: If the 100 students each spent one hour in each of their courses each day, the amount of time spent in each course each day would be 100 hours. The simulated data showed that the median number of hours spent in each class was 77. These findings indicate that individual study space would not be fully utilized if there was a carrel for every student and if students used time to file requests and to change from work area to work area. Analysis of the data suggested that most of the demands for space could be met if individual study space was supplied for 90% of the population. The demands for help from the teacher varied from 6 to 22 requests a day over a 28-day period. Analyses of these data suggested that on most days teachers could meet with students on an individual basis rather than in groups.	Appendix C, pages 20-28. Tables I, II, III.

Table II. Summary of the Major Results of the Nine System Analyses (cont)

Nine System Analysis Studies	Major Results	References
3. Brigham Young University Laboratory School Autonomous Scheduling Procedures (cont)	Analysis of the demands for testing indicated that the needs could range from 9 to 29 requests in any specific course on a given day. The need for separate testing spaces for each course were suggested by the analysis of data. The problems of effectively utilizing teaching staff for help and testing could be handled by daily automated scheduling procedures.	
4. Nova High School 10th-Grade Social Studies Course	1. Systems analysis and computer simulation of the 10th-grade social studies course identified the following problems in the course: The poor teacher/student ratio of 1/50 reduces the amount of individual instruction that can be given. Teachers tend to either work with the groups as a whole or students work independently. Forty-six percent of the student's time is spent either in large group or independent study. Seventeen percent of class time is devoted to lecture presentations by teachers. Only three percent of class time is used for presentations that are mediated by nonhuman means. Recording lectures for playback in the course the following year could save considerable teacher time for individual or small group work in the future. However, the emphasis on the development of new teaching materials makes teachers hesitate to use the same lecture the next year. 2. The use of an instructional management information system that would automatically monitor student performance and select those students most in need of teacher help would help the teachers to take a more individualized approach to the students.	Appendix D, pages 5-13. Table I.

Table II. Summary of the Major Results of the Nine System Analyses (cont)

Nine System Analysis Studies	Major Results	References
4. Nova High School 10th-Grade Social Studies Course (cont)	3. The number of carrels and the space in the learning resource centers is grossly insufficient for use in courses that are organized on a continuous progress basis. Plans should be considered to increase the spaces for independent study.	
5. Theodore High School Biology Course	1. Simulation of the progress of students through the 10 units that comprise the regular biology course shows the effects of requiring all students to accomplish the same amount of work by the end of the first, second, third, and last quarter. While the average amount of time all students spend in each unit cannot be predicted by an independent analysis of the relative importance of units as shown in the study guide, the average can be predicted by simulating student progress as being dependent merely on the number of days the student has already consumed working in the course.	Appendix E, Table I.
	2. Of the total 156 students enrolled in the course during its 35 weeks of operation, 54% completed the 10th unit.	Appendix E, Table II.
6. Theodore High School Biology Course Experimental Version	1. An experimental version of the biology course was modeled by computer simulation to determine the effects of lifting the requirement that all students achieve the same amount of progress. This study showed that some students would finish the normal 35 week course as early as the 15th week and that if it were extended to the 54th week, 82% of all students would complete the 10 units.	Appendix E, Table III.

Table II. Summary of the Major Results of the Nine System Analyses (cont)

Nine System Analysis Studies	Major Results	References
6. Theodore High School Biology Course Experimental Version (cont)	2. Compared to the regular 35 week course, simulating the 54 week experimental version showed that the latter would save 93 weeks of student time in achieving 82% success. This degree of success can be compared to the 54% degree of success of the regular course.	Appendix E, Tables II and III. See, also, discussion on pages 8 and 9.
7. Buena Vista High School 11th-Grade English Course	1. Simulation of the course shows that the selection of an activity for a particular day depended on whether it was a day when the class was scheduled to use the television facility or not, and whether or not the class remained intact as a large group.	Appendix F, pages 8, 9.
	2. Student time was devoted to activities approximately as follows: 23% to lectures via television; 37% to teacher-centered discussion, recitation or non-television lecture; 11% to testing and correcting tests; 23% to independent study; and the remaining 6% to student panels via television.	Appendix F, Table I.
	3. Resources utilized by the course per week include: the time of the 150 students and three teachers (50 minutes daily for five days); one to one and one-half hours of the head teacher's time to set-up and prepare for the telelessons; one and one-quarter hours of television air time; and six to seven hours of an artist's time to prepare visual materials. The school's television facility to support all courses includes a director, an assistant director, a visual arts technician, and 36 trained student cameramen.	Appendix F, page 5.

Table II. Summary of the Major Results of the Nine System Analyses (cont)

Nine System Analysis Studies	Major Results	References
8. Buena Vista High School: Design of an English Course Combining Telelessons with Individual Progress	1. This analysis produced a design of an English course that combines the work normally accomplished during the last two years of high school. The plan enables students to finish the combined course in three, four, or five semesters, depending on their individual abilities. Approximately one-half of student time is allocated to teacher-centered activities including telelessons while the other half is spent in individual study of programmed materials, texts, films, tapes, and records.	Appendix F, page 16.
9. Garber High School Mathematics Curriculum	1. Simulation of the new plan operating for six years shows that in June 1971, 745 of the 962 students in the school will be enrolled in mathematics courses.	Appendix G, Table II.
	2. Six of the 29 courses will have no enrollment; three courses will contain only first-year students; three courses will contain second-year students, and a very few slow third-year students; four courses will consist of third-year students and a small number of slow fourth-year students; the remaining 13 courses will be made up from a mixture of third-, fourth-, fifth-, and sixth-year students.	Appendix G, Table II.
	3. The class leaving Garber High School in June 1971 is predicted by simulation as having earned 607 course credits in 24 different mathematics courses. This represents an average of 4.9 courses per student in this six-year school.	Appendix G, page 17.

Table II. Summary of the Major Results of the Nine System Analyses (cont)

Nine System Analysis Studies	Major Results	References
9. Garber High School Mathematics Curriculum (cont)	4. Simulation shows that operation of the Garber High School plan will result in a high mobility of students. Because many courses are organized for individual progress, students will be changing courses in small groups of from two to 10, every 45 days. Simulation shows that during the three weeks at the end of June 1971, at least 88 individual student transfers between 14 different courses will occur.	Appendix G, Table IV.
	5. Since each of the approximately 750 students in mathematics will be taking about 15 tests per year, the department will need to give about 10,000 such tests. Giving these in the individual mode poses administrative problems.	

2. Areas of Difference Between Automated Systems and the Counselors

The automated appraisal programs identified more students as overachievers and as potential dropouts than did either of the two counselors. Both of these differences were clearly attributable to the fact that the computer program was generally more pessimistic in predicting the future achievement of students in the lower aptitude levels. A modification of the computer program to change this one function would produce a much greater similarity between the counselors and the automated procedures.

(It was the feeling of the researchers that the computer program provided an excellent model for studying some of the counselor's decision rules. In addition, there was a strong subjective feeling of confidence that the procedure also provided a good way of understanding the counselor's appraisal behavior.)

The schedules made by the students under the automated conditions tended to differ from the schedules made with the counselor present. This was true not only in the specific courses which were selected, but also in the number of course schedules that were completed. In this latter case, the computer was more permissive than the counselors. It neither compelled the student to make a complete program of courses nor compelled him to make any attempt at preparation of a program.

Two interesting differences showed order effects. When the machine interview was administered first, there were greater differences between the schedule produced with machine and the schedule produced with the counselor than occurred when the counselor interview was first. A number of observations led to the conclusion that the counselor exerted more influence on the students than did the interview program.

Also, a significantly larger number of students (F significant beyond .05 level) expressed concern over problems to the counselor when the machine interview occurred first in the sequence. This difference may be attributable to the fact that the computer interview always asked students if they had problems, while the counselors may not have asked. In addition, some students stated emphatically that they felt that the confidentiality of the machine interview was a strong point in its favor.

3. Reaction of Students to the Automated Procedure

Different sets of attitude questions were presented to the participating students following the automated interview and the human counseling interview. The questionnaire items were tailored to the two different situations. Although no direct comparison can be made, the mean scores on both attitude scales tended to be in the positive direction. The scoring was such that if one-half the items were answered negatively and one-half positively, the total score would be 90 on either of the two scales. The actual mean score on the attitude scale that followed the automated interview was 105, and the actual mean score on the attitude scale that followed the human counselor interview was 119. There were wide individual differences among students in each group. A few students seemed to react very positively to the machine and a few expressed a strong preference for the counselor.

In the standardized post-interview, 53% of the students indicated that the machine was not able to take into consideration all of the data necessary to make adequate plans for high school. Most of these students felt the machine did not give enough consideration to personal interests and personality variables.

Fifty-six percent of the students expressed some reservation about course plans made with computer assistance, whereas only 20% had reservations about course plans made with the counselor.

Six percent of the students reported that the computer interview bored them and made them restless; 26% of the students felt bothered by the fact that the computer did not give them any reassurance as to whether their choices were appropriate.

Only one of the 40 students in the study chose to terminate the machine interview before making 10th-year course plans.

CHAPTER IV. DISCUSSION AND CONCLUSIONS

A. USES FOR SYSTEM ANALYSIS IN EDUCATION

Two distinct uses for system analysis in education were defined in the present study. One use serves the immediate needs that a school may have to examine and possibly change present instructional procedures. In this context, system analysis is a powerful tool for locating and defining current problems in instructional systems and for exploring the feasibility of changes to existing systems. A second use made of system analysis is to design new educational systems. In this usage, the analysis provides a means for giving structure to what otherwise may be fairly abstract ideas.

1. Use of System Analysis Procedures for Improving Existing Systems

The system analysis procedures defined by this study can be used to help make changes to an existing system and to help in developing plans for new systems. These two kinds of applications are illustrated by the work done at Theodore High School and Garber High School (see Appendixes E and G, respectively).

a. Modifying an Existing System at Theodore High School

After the descriptive data were collected at Theodore High School and the system description of the 10th-grade biology course was written, project personnel met with the principal, the teacher of the biology course, the head of the social studies department, and the head of the language arts department. These meetings were held to review the system description and to generate ideas for improving the design of continuous progress courses. As a result of this interaction, school personnel presented a number of ideas for the use of data processing technology to improve instruction in the school. The ideas included: new procedures for keeping an up-to-date record of every student's performance; new procedures for identifying students who were performing below expectancy; and new procedures for relaying data on progress from all courses to a counselor so that the student could be helped in his total adjustment to school.

In the computer simulation study of the 10th-grade biology course, the effects of the group time constraints on student performance were defined. An experimental model was developed that showed how students would perform if the group time constraints were removed. The next step will be to meet with school personnel to study the simulation data and to plan further changes to the continuous progress procedures used in this course.

b. Planning a New System at Garber High School

Project personnel developed a system description of the plan for a six-year mathematics curriculum at Garber High School and helped school personnel in estimating the probable distribution of students at specific points in the system. Students were simulated as going through the curriculum for six years. These data will be useful to school personnel in predicting their needs for resources, and in suggesting improvements to be made to the plan before it is fully implemented. System analysis procedures could be used to help the school develop its plan further.

2. Exploration of New Designs by Computer

In this case, system analysis and computer simulation procedures were used to explore new ideas for developing school organizations. The simulation study of the autonomous scheduling procedures for the continuous progress plan (see Table II) showed the resource demands for teachers and space that would result from use of these procedures. This approach allows freedom in exploring ideas, since the purpose is not to help a particular school with a specific planning problem. The simulation capability is useful in this kind of application in helping designers develop more exact definitions of the model, for exploring the logical consequences of various alternative designs, and for making communication between designers more explicit.

B. VALIDITY OF SIMULATED DATA

The problem of validity in the use of computer simulation for planning school organization can be considered from opposing points of view. One view is that the simulated model should conform to data from the real world. The opposing view is that the simulated model represents what the real world should be. The first view implies that the model should be changed until it conforms to data that describe the real world. The second view implies that the real world should be manipulated until it produces data like that produced by the model.

The simulation of the biology course at Theodore High School helps to illustrate this problem of validity. Two simulated models were developed with the simulation capability. One model simulated the course as it actually existed. The simulated data were compared to data from the real course and the validity of the model was suggested by the similarity between the two sets of data. In the second model--the experimental model--students were simulated as going through the biology course without the group time constraints. If the school changed operating procedures to conform to the experimental model, then the data from the model could be used to evaluate the success of the changes. The point of view could be taken that the changes would be successful when they produce data like those produced by the experimental model.

In actual use a compromise would probably be made between these two extreme points of view. Attempts to change the school in the direction of the experimental model might result in identification of problems that had not been considered in the simulated experimental plan. These new data might be used to change the model so that it accounted for the new discoveries.

C. IMPLICATIONS FOR THE ORGANIZATION OF SCHOOLS

The survey of innovating schools (see Appendix A) showed that there is an increasing concern in American secondary education with the problem of finding ways to individualize instruction. Many of the schools that were surveyed are increasing the opportunity for students to work independently. However, the system analyses at the five schools included in this study demonstrated that there are many problems that must be faced in moving from group-centered instruction to individual-centered instruction.

Some of the major problems that were uncovered are discussed below:

1. Conflicts Between Group and Individual Instruction

Our education system has been group-centered for such a long time that few people are aware of the extent to which our thinking is dominated by this point of view. An apparent confusion in thinking on the part of many people who are planning for individualized instruction is evident. This confusion is illustrated by the plans in some schools to use closed-circuit television for the presentation of materials for individual viewing in the misconception that this enables individual progress. Yet the choice of closed-circuit television as a medium for presenting materials must assume that many students will have the need to see the same materials at the same time, since only a few originating sources can transmit at the same time. Obviously, if students are really free to vary in their progress as individuals, there will be many demands at the same time for different programs.

Similarly, schools that group students for instructional purposes also show a lack of awareness of the meaning of individual instruction. If students are really allowed to progress in accord with their individual abilities, their progress will, in time, be so dispersed that it will be unusual to find enough students working on the same point in a course for a group meeting. The simulation of the ninth-grade algebra course at Brigham Young University Laboratory School illustrated this problem (see Appendix C).

As long as teachers feel that they must meet students in groups, or that they must get students through the course by the end of the year so that all the students will be ready to take the next course at the same time, procedures will be used that encourage the students to perform as a group. The Theodore High School study illustrated this point (see Appendix E). Setting specific milestones and prohibiting significant variance in individual progress resulted in students pacing themselves so the group was fairly homogeneous. Consequently, the full advantages of individual instruction were not realized. The following reasons probably explain this tendency of teachers to cling to group standards for student performance: (1) There is no experience available on which to develop a procedure for determining the expected performance for an individual. (2) Teachers probably feel that some kinds of goals must be set to motivate students. (The variation in student pacing does show the effects of the group goals, but increased variation in mastery is the price that is paid.) (3) Setting group goals simplifies the information processing problems that develop when students are free to work in an individual mode. It is much easier to check all student progress periodically against one time goal than it is to check all students continuously against individual progress goals. (4) Setting group goals reduces the problem of finding things to do for the students who finish a course early. (5) Lack of resources may interfere. There may not be enough teachers, space, or materials.

In summary, the study of the innovating schools that were investigated in this project reveals that there is really no existing course that is completely individualized as far as the time variation dimension is concerned. Educators need to become much more sensitive to the fact that their experience in group-centered education will make it difficult for them to develop an educational system that is truly individual-centered. The experimental simulated data produced in the Theodore High School study (see Appendix E) provides a reasonable estimate of the kinds of distribution in time variation that would occur if students were free to set their own pace in learning.

2. Resources Required for Individualizing Instruction

Developing a school for individualization places heavy demand on resources. This is a critical problem that requires careful consideration and further study. The problems noted in the present study are considered in terms of: (a) human resources; (b) the deployment of resources; and (c) the use of information.

a. Human Resources

No school as yet has had sufficient human resources to develop individualized instruction throughout the school. In all of the schools studied in this project, extra human resources were required to take the steps that have been taken. At the Brigham Young Laboratory School extra help was obtained from graduate students and funds were obtained to provide free time for the teaching staff to construct materials. At Theodore High School extra funds were obtained to employ teachers over the summer to develop materials. For example, three man-months were required to develop the first version of the study guide and a first version of unit tests for the biology courses. This expenditure of time was necessary even though the Biological Sciences Curriculum Study (BSCS) materials were used in the course. At Nova High School one teacher was freed almost entirely of teaching duties during the 1963-1964 school year to produce continuous progress study guides for 10th-grade social studies.

The amount of time that will be required to develop adequate materials for individualized instruction is difficult to estimate. The construction of adequate study guides and course tests requires time for testing the materials with students and revising them. In the Theodore High School biology course, for example, the three-month summer interval did not provide nearly enough time for developing unit tests that would help the instructor diagnose student weaknesses adequately. In addition, added time was needed to make changes to the BSCS course materials so that it would fit the instructor's plan. It is estimated that approximately two man-years would be required to develop adequate materials for the biology course. This figure assumes that study guides would be adequately tested, that BSCS materials would be modified, and that reliable objective unit tests useful for diagnosing learning problems would be developed. Furthermore, continuing modification is essential to keep the course information current.

If materials for individualized instruction are developed for one course, they should also be developed for other courses in the curriculum. <u>Only when materials for the whole curriculum are developed will schools really individualize instruction</u>. This statement is supported by the findings from the survey of innovating schools. The programmed materials used most extensively across the country were the TEMAC mathematics series for two reasons: (1) School personnel are interested in using these materials because they include most of the materials needed for teaching a complete course and little additional planning and development is required of the teacher. (2) In addition, the series provides materials for a number of courses in an available sequence so students may begin the next course if they complete one course early.

Although the size of the production task requires that many materials for individualized instruction will need to be developed by publishers, curriculum study groups, etc., the teachers responsible for courses should still have some involvement in the adaptation of the study guides that direct the students' behavior in the course.

If the course procedures are so rigidly defined that the teacher has no opportunity to modify and adapt them, he will resist their use. The production cycle should be designed so an individual teacher can request the modifications that he desires.

Some means of providing additional resources will be required if schools are to make major strides in developing individualized instruction.

In addition to adding resources, teachers must be trained in usage of the new resources. The survey of innovating schools and the analyses at the five schools showed that it is difficult to change ingrained behavior patterns. Teachers show a strong tendency to think about teaching from a group-centered point of view, and seem to be slow to adopt an experimental attitude toward instruction. Some methods need to be developed to change teachers' attitudes and concepts regarding innovation and individualization.

b. Deployment of Resources

Another problem critical in planning for individualized instruction is the deployment of human and material resources. Many considerations are important. What kind of space and equipment are needed? How should teaching personnel be assigned? How should students be scheduled?

The amount and kind of space for an individualized instructional plan remains a problem that still must be solved. A number of different solutions are being tried at the schools included in the analysis. At Brigham Young University Laboratory School students conduct their individual work in a large room with individual carrels for independent study. Each student is assigned to a carrel which has three wooden sides extending about three feet above the desk level. The carrels are placed in rows. The only way that the teacher or teaching assistants can see the students is by walking between the rows. All of the students in the class are not visible at one time to any one observer. At Theodore High School mathematics is conducted in a large room where all of the students are visible at one time to the teachers present in the room. Students obtain individual help by going to the teacher's desk at the front of the room. Students who need to take tests take them in one corner of the room that is reserved for testing. At Nova High School a limited number of special carrels are available in the learning resource centers. If a whole class of students at Nova High School were to be scheduled to work on an individual basis, most of the study would have to be done by the students in a conventional classroom because not enough carrel spaces are available to serve an entire class simultaneously.

Although further research is needed to define the requirements for study space, the experience of the various schools suggest the following guidelines:

- If carrels are used for independent study, it is desirable that the students and teaching personnel be in view of each other. Carrels that hide the student from view tend to isolate the student and make the job of monitoring more difficult.

- Rather than plan for the development of a general-purpose carrel for individual study, different kinds of carrels should be developed for different kinds of uses.

- Enough carrels should be available so that every student has a place to work.

- The amount of space required to meet demands can be predicted by simulating students going through the plan. The experimental simulation studies of Garber and Theodore High Schools, and the Brigham Young University Laboratory School illustrate uses of the simulation capability for this purpose.

The arrangement of teachers and students for continuous progress courses is a problem that also requires further study. However, the work conducted in this project does suggest the following guidelines for serious consideration in planning:

- Students should not be required to obtain help from the teacher in groups. Resources should be deployed in such a way that the teachers can meet with individuals.

- Group activities should be planned when objectives exist that require group interaction. Efforts should be made to make group activities independent of the sequence of learning that occurs in individual study.

- Schools should seriously consider autonomous scheduling procedures in which students schedule themselves to work on their various courses when and for the length of times that they require. The five-course autonomous scheduling model that is simulated and discussed in Appendix C suggests the feasibility of this procedure. Initial trials of this procedure with 50 students on a limited basis at Theodore High School supports the feasibility of this plan.

- Autonomous scheduling procedures probably require that teachers should be permanently assigned to a work space area containing enough desks or carrels for individual study, a teacher studio or an office with a view of the study space, laboratory and conference facilities, and a testing space. Students would go to the work areas to do their work on the courses.

c. Use of Information

(1) Information for Managing Courses

One of the most pressing areas in developing courses for individualized instruction is the problem of handling sufficient information to keep track of students. One reason the lockstep system has persisted for so long may be that this method is designed to reduce the information-processing problems of the teacher. Students progress in unison, take tests simultaneously, and are given identical assignments. In the continuous progress plan school, on the other hand, at any one time all the students may be working at different points in the curriculum. Each student's need for help from the teacher may be different. Every day a few students may be taking tests. A great deal of teacher time is devoted to monitoring and evaluating student performance. In fact, it is unlikely that individual progress courses on a large scale within a school would be possible without a computer-based system to keep track of the progress of students. Extrapolation from the Garber High School simulation data to the operation of a whole school suggests that with a population of 900 students, there would be from 30 to 40 changes between courses and about 300 mastery tests daily. The analysis of this problem strongly supports the need for the development of advanced information processing procedures that will provide a solution to this information problem. What is needed is development of an instructional management information system that provides the following services:

- Collects and stores information on student performance and student expectancies.

- Provides the instructional staff with information displays that identify students who are having trouble.

- Orders information about student needs so that instructional personnel can spend their time working on the most pressing problems. Some specifications for such a system are the results of a system analysis that led to a design for a total continuous progress school (see Appendix C).

The increased capability to obtain and analyze data on student performance that the instructional management information system would provide should also improve the potential for course development. Performance data could be used to evaluate the materials and procedures in the course and they could be systematically changed until criterion behavior is obtained.

(2) Scheduling Resources

If a school system is to be maximally responsive to the needs of individuals, there should be a capability for scheduling resources on a day-to-day basis so that they can be used in the most efficient manner. With the current development in time-sharing computers it is now technically feasible to develop real time information processing centers in schools that continually accept requests for resources by students and teachers, and that develop schedules for the use of resources. These schedules would make optimal use of the resources.

A number of detailed suggestions for the use of such an information processing center are described in connection with each of the studies reported in Appendixes C, D, E, F, and G:

D. CONCLUSIONS FROM THE SPECIAL COUNSELING STUDY

The following conclusions were drawn from this study:

- Computer simulation can be used for building and testing a model of complex counselor behavior. The model is explicit, communicable, and detailed in definition.
- A comparison of the automated appraisal model with the behavior of the human counselors in the validation study indicated that 75% of the statements produced by the model were valid. Minor revision to the computer program would markedly increase the validity of the model.
- A comparison of the automated interview with the human counselors showed that there were differences in the high school programs produced by students in the two situations. The study indicated that further work would be required to produce a program that could help students prepare schedules identical to ones produced when the counselors helped them.
- A study of the students' attitudes toward the automated and human counseling showed no pronounced group differences. However, there were marked individual differences. Some students preferred the human counselor and some students preferred the machine. A few students could not be deterred from their belief that a human was controlling the responses of the teletype during the automated interview.
- The study suggested the feasibility of automated appraisal, automated student interviewing, and automated storage and retrieval of student information.

E. TRENDS IN INNOVATION IMPLIED BY THE SURVEY

Some interesting trends were suggested by the questionnaire data and field site visits. These concerned the influences for innovation in schools, the growing concern for individualization, and the increase in organizational innovation.

1. Influences for Innovation in Schools

In the analysis of the survey data it was pointed out that schools that innovated in one of three broad areas--instruction, organization, and educational data processing--also tended to innovate in other areas. However, within the area of instruction a contradictory tendency was noted. Although innovating schools frequently tried some innovation in instruction, in general only a few innovations were being tried and these were usually restricted to one or two courses. The field site visits lend strong support to the hypothesis that leaders such as principals and superintendents in the schools are usually responsible for innovation. In all of the schools visited it appeared that innovations were started by the head of the administration. The leaders who were responsible for initiating innovation were, in general, people who either had a specific concept they wished to implement (such as the continuous progress plan) or they were interested in stimulating an experimental attitude and an interest in change within the school. Despite the efforts of the leaders, the instructional staff tended to maintain a relatively restricted approach to innovation in instruction. Although most of the educational leaders operated in a permissive and democratic manner and tried to make the environment receptive for innovation, only a few teachers took advantage of the opportunity to innovate.

In schools where the educational leader was trying to implement a concept, a great deal of additional effort was placed on trying to train the staff. Observation of the patient struggle of educational leaders trying to arouse interest in their teaching staff and trying to communicate their concepts showed this to be a real problem area. Teachers who are trained in traditional group-centered methods and who relish their sense of academic freedom are slow to make radical changes in their teaching.

Several leaders took a more autocratic approach to facilitating innovation in instruction. In these cases the total school was set up for team teaching or the use of closed-circuit television. Grass roots support and cooperation from the teaching staff was not nurtured in the patient manner described above. This method did not necessarily lead to a real change in teacher behavior. Teachers who opposed the innovation and were scheduled to times and places for team teaching still managed to avoid working creatively as part of the team.

2. Trends Toward Individualization

A number of facts suggest an increasing trend in the direction of individualized instruction. The development by several schools of continuous progress plan courses, the attempts to remove the grade barrier by developing nongraded plans, and the large amount of time allocated for independent study in most team teaching plans all show this trend. In addition, discussions with educators at the field sites showed that there was concern for this problem. Many of the schools in the survey indicated that their school objectives contained statements of intent to adapt education to the individual differences between students, and many were concerned with finding ways to increase this kind of opportunity. In general, there is a tendency to view the brighter, more academically oriented students as the ones who will benefit most from independent study. In some schools, independent study is a reward for high achievement. There is an opposing tendency to believe that the slower and less academically inclined students need to be treated in a group situation under the close supervision of a teacher. In the opinion of the authors, this belief is ill-founded. Independent study is not necessarily a poor method for slow learners. The actual fault is a lack of adequate self-study materials for the slow learner who is undoubtedly also a relatively poor reader. By placing them in a typical group-centered situation where they can get information by lecture or demonstration solves an immediate problem. A better solution would be to develop self-study materials for poor readers such as films or audio tapes.

3. Increase in Organizational Innovation

The continuous progress plan shows a radical departure from the traditional way of organizing instruction. Although few schools have been able so far to attempt such a radical break with the traditional lockstep, many schools are trying to make some organizational innovation. Team teaching is a trend in this direction. A frequent pattern that was observed in team teaching was the use of a 70-minute class period. This longer block of time allowed the team to plan more varied activities. Time was most frequently divided between large group presentations, small group discussions, independent study, and testing.

Another trend toward variation of the organizational pattern is the modular schedule. A number of schools are developing schedules in which the basic unit is a 20-minute module. Various courses are assigned varying combinations of modules. A course in biology might meet on one day in a two-module period for lecture, meet on a second day in a one-module period for discussion, and meet on a third day in a four-module period for laboratory work. The major problem associated with modular schedules is that the course is locked into the fixed pattern for the whole semester. It is highly unlikely that a modular allocation of time made at the beginning of the year will meet the needs of the course from week to week during the semester.

These trends toward individualization and experimentation with the organization of instruction give promise of significant change in American education in the coming years.

CHAPTER V. RECOMMENDATIONS FOR FURTHER STUDY

A. INTRODUCTION

A substantial part of the value gained from an exploratory study such as this one is the precision gained, over the original statement, in defining the problem. When the project began, the authors outlined some fairly general goals that can be summarized simply as a desire to explore the uses of system technology (system analysis and computer simulation) in a study of school organization. A concern with innovation and a focus on instruction led project personnel to search out and work with the specific schools described in Appendixes C through G. Throughout the study, project personnel tended to search for ways to improve instruction; it is this bias along with the authors' skills in system analysis that were major factors in directing the exploration.

As a result of the explorations made in this project, the general goals were separated into four areas and defined. The first of these areas, delimited early in the project, was defined in the study of the use of information processing in counseling students for educational planning. This work is discussed in Appendix H. A second area that was delimited was the use of information processing in today's classrooms to help instructors be cognizant of students as individuals. This area was alluded to in discussing the implications of the results of the five studies (Appendixes C through G) for the use of data processing in instruction. A third area that was delimited was the general need for instructional personnel to learn how to apply system techniques to the design of courses. This problem emerged in discussing the role of the instructor and the use of media in each of the five studies reported in Appendixes C through G. A fourth area pertained to the procedures developed in this project for the use of system techniques to improve current classroom instruction.

The project has produced suggestions for continued activity in each of the above four areas. As a direct result of one suggestion growing out of this project, work in the area of using information processing techniques in counseling, is continuing under the auspices of the U. S. Office of Education, Division of Adult and Vocational Research. This three-year effort is aimed at producing a computer-based system to assist counselors in helping students make vocational decisions.

B. RECOMMENDATIONS

With respect to the other three areas that were delimited, the authors of this report make the following three recommendations.

Recommendation 1--A continuing study of the use of information processing in the classroom should be made. During the conduct of the present project, preliminary design ideas for an information management system were developed for use with individual progress courses (Reference 20). Regardless of whether a course is individualized or not, there is a need in today's classroom to collect, store, and display student information in such a way that it can be used in the instructional process. Information regarded as permanent records (cumulative folder material) and information on current performance (tests, activities, projects completed, etc.) should be combined and displayed so that instructors and counselors are made aware of the immediate needs of individual students. Modern information processing technology makes it feasible to "track" each student in a school and to alert staff personnel when the student is outside expected limits.

Such a study should seek to answer the following questions:

- What are the general requirements for an instructional management system that will serve a wide range of schools, and what are the unique requirements that characterize specific schools?
- The concept of "tracking" implies that the system will predict academic achievement for a student in a course and keep track of his current status relative to the prediction. What are the specific aptitude measures that can be used to make such predictions? How general are these; must a different index be used for each course, each school, etc.?
- How can provisions be made to ensure that such a system takes into account the aptitudes, abilities, values, and needs of each student as an individual in establishing expected performance?
- A study needs to be made of both an "off-line" system (in which data are collected for a period of time and taken to a computer for processing) and an "on-line" system (assuming that a school has direct and continuous access to a computer through appropriate "input-output" devices). Although the on-line system is undoubtedly the system of the future, it may be necessary to get to that point through an initial off-line system.

With respect to the future prospects in education for individualizing instruction, two major deterrents were identified in the present project and are discussed in Chapter IV. The first of these is the problem of providing empirically developed materials for individualized instruction; the second is related to the recommendation for a computer-based system to monitor student progress. The studies at Brigham Young University Laboratory School, Theodore High School, and Garber High School clearly showed that the extension of individualized instruction to include individual progress will not be possible on a wide scale in any school unless the school has a system whereby it can track its students. The requirements for such a system are discussed in Appendix E. The tracking of students in an individualized course is only one special case of the general need in any course to provide instructors, counselors, principals, and students themselves with timely and useful information that can be used to make decisions related to instruction.

Recommendation 2--Training in the use of system technology for planning instruction is needed for administrators, instructional leaders, and candidates for advanced degrees in education. The present study has found that the leaders of school organizations play a very important role in innovation (Appendix A); that application of a systems approach to the planning of courses can be very beneficial (Appendixes E and G); and that the lack of properly designed instructional materials is a major barrier to individualization (Chapter IV). It is hypothesized that by giving selected school leaders intensive training in the system approach to developing instructional systems, the rate and quality of innovation will be accelerated in the schools from which these leaders are drawn.

Recommendation 3--The authors recommend continued work in the application of system analysis and simulation to improve instruction in the five schools involved in the present exploratory study. While further application has an aspect of value to the specific schools involved, the ultimate purpose for continuation is to use these schools as laboratories to develop procedures in the use of system analysis methods for managing change in secondary schools.

In the present project the improvement of instruction was initially viewed as consisting of designing computer based systems to aid in the instructional process with an eye to the future when ample cheap computing power is available to secondary schools. The work done in conjunction with the Brigham Young University Laboratory School, for example, resulted in part in extensive detailed designs for a continuous progress school, including a computer-based tracking system. As the present project progressed, however, a second and considerably different use for system analysis began to be defined. Project personnel began to see the possibility of using system analysis and computer simulation as a viable tool for improving instruction in the present. We became acutely aware that the work done with personnel from the participating schools in defining an actual course* as a system led spontaneously to the identification of organizational problems and to many ideas for their solution.

*In the case of Garber High School, the total mathematics curriculum was defined as a system (Appendix G).

The phasing of the present study was such that it ended with the simulation studies reported in Appendixes C through G; therefore the authors have had no opportunity to interact with school personnel about the results of the simulation. Earlier interchanges with school officials indicated a high degree of interest in the outcome of simulation. The authors were encouraged to believe that viewing these results would lead to specific changes in school organization and to another cycle of simulation studies. These procedures promise to provide a very effective means for both inciting and affecting change in school organization.

The ultimate product of such work should be procedures for managing change. These procedures should be usable by individual schools. The product should enable a school to establish a formal instructional improvement function within their organization. This function should be able to define a specific organization (course, department, school, etc.) as a system, identifying problems, propose solutions, implement change and assess results. The nucleus for these procedures would be a capability for school personnel to model the system on computer, much as the present authors did with the systems described in this report. This capability can be developed from the EDSIM program used in the present study by converting it to a system for nonprogrammers. Such a system would enable school personnel to construct models of instructional systems by using an input device such as a teletypewriter, connected to a computer. Models produced in this way could be used as a basis for critically examining current practices as well as for simulating the effects of proposed changes to a current system.

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APPENDIX A

RESULTS OF THE SURVEY OF INNOVATING SCHOOLS

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Appendix A

A. INTRODUCTION

This appendix summarizes the results of the survey of innovating schools, and identifies and discusses some of the apparent trends in educational innovation. The procedures used to collect the data for the survey are described in Chapter II.

B. RESULTS OF THE SURVEY

The questionnaires that were sent to the innovating schools (Appendix A, Attachment 3) asked for information about the following kinds of innovation: (1) teaching machines with programmed learning; (2) programmed learning without teaching machines; (3) educational television; (4) closed-circuit television; (5) language laboratories; (6) flexible scheduling; (7) ungraded programs; (8) team teaching; (9) continuous progress plans; and (10) electronic data processing. Under electronic data processing, information about the following applications was requested: (a) scheduling--class loading and assignment; (b) scheduling--constructing master schedules; (c) scheduling--printing class cards, rosters, etc.; (d) attendance accounting; (e) grade reporting; and (f) test scoring and analysis.

These 16 innovations can be categorized under three general headings--instruction, organization, and electronic data processing. The first five are innovations that are used for the presentation of instruction. The sixth through the ninth are innovations in the way that instruction is organized, and the 10th through the 16th (a-f) are applications of electronic data processing.

Table I shows the frequencies of schools involved in the three general kinds of innovation. These data are based upon the 89 questionnaires returned in the survey. Column one shows the number of schools that were involved in only one of three kinds of innovation--instructional, organizational, or use of educational data processing (EPD). Column two shows the number of schools that were involved in two types of major innovation, and column three shows the number of schools that were involved in all three types of innovation.

Table I shows that 80 schools (90% of those returning questionnaires) have innovation in instruction, 74 schools (72%) reported innovation in organization, and only 39 schools (44%) have some involvement in educational data processing.

Twenty-six schools are involved in both instructional and organizational innovation; only five schools are involved in both instructional innovation and educational data processing; no schools are involved in both organizational

Appendix A (cont)

Table I. Frequencies of Schools Using Various Major Kinds of Innovation

Types of Major Innovation	Number of Schools Using Only One Type of Major Innovation	Number of Schools Using Two Types of Major Innovations	Number of Schools Using Three Types of Major Innovations
Instructional	20		
Organizational	14		
Educational Data Processing	0		
Instructional + Organizational		26	
Instructional + Educational Data Processing		5	
Organizational + Educational Data Processing		0	
Instructional + Organizational + Educational Data Processing			34
Totals	34	31	34

Appendix A (cont)

innovation and electronic data processing alone. These data suggest that some relationship exists between instructional innovation and organizational innovation. This is probably because innovations such as programmed instruction tend to conflict with the usual organizational arrangement of classrooms. These materials require that the student spend his time in independent study, and they allow the student to progress at his own rate through the materials. The continuous progress plan, an organization plan that has students spending a large part of their time in independent study, was developed to facilitate the use of programmed learning materials. Certain kinds of media apparently tend to encourage the organization of teachers into teams. The use of closed-circuit television (CCTV), for example, often leads to an arrangement where one teacher lectures via CCTV for part of the class period, and other teachers participate with the students in discussions after the television presentation.

The negligible interdependence between organizational innovation and use of electronic data processing (EDP) is surprising. The data gathered during this study indicate that EDP was being used on the periphery of instruction to help handle routine data processing tasks such as attendance accounting, grade reporting, and test scoring. At the time that the survey data were collected, the use of computers in building master schedules and in developing flexible modular schedules was still in the research phase.

The development of new computer techniques for planning master schedules should increase the capability of schools to make innovations in the organization of instruction, therefore an increased correlation between the use of EDP and changes in organization is expected in the future.

The fact that 38% of the 89 schools have some innovation that involves all three areas suggests the interpretation that schools that innovate are likely to innovate in a number of different areas. One reason for this could be that leaders in the schools encourage innovation throughout the schools.

C. INSTRUCTIONAL INNOVATION (MEDIA)

Table II shows the number of schools that were using varying kinds of instructional innovations. Thirty-two of the 80 schools involved in instructional innovation only have innovation of one type. Ninety-six percent of the schools that are involved in instructional innovation had three or fewer instructional innovations. These data suggest that, although schools may innovate in a number of broad areas (e.g., both instruction and data processing), those that innovate in the instructional area tend to concentrate their efforts in a small number of instructional innovations. One explanation may be that leaders are able to interest only a few teachers in trying innovations. Our discussions with the leaders of the schools that were visited tended to support this interpretation.

Appendix A (cont)

Table II. Frequencies of Schools Using a Variety of Instructional Innovations

	Number of Schools	Number of Instructional Innovations in Use
	32	1
	28	2
	17	3
	3	4+
Total	80	10+

Appendix A (cont)

Table III shows the number of schools and the number of courses in each school using programmed instructional materials associated with teaching machines. A total of eight schools report some use of programmed instruction with machine. Fifty percent of the schools are using the machines in one course only. Seventy-five percent of the schools involve only two or fewer courses. These figures suggest that schools have a tendency to experiment with innovation in only a few courses.

Table IV shows the number of courses in each school and the number of schools that use programmed instructional materials without teaching machines. Forty-three of the schools, a little more than 50% of the schools involved in instructional innovation, are using programmed instruction. Eighty-one percent of those schools using programmed instructional materials without teaching machines are using the materials in four or fewer courses. Again, a limited use of instructional innovations is suggested. The conservatism is even more apparent when the number of subject areas included is considered. Table V shows the number of schools and the number of subject areas involved in the use of programmed instruction without machines. The number of subject areas is more meaningful than the number of courses because the same subject-matter area or the same program can be used in several different courses. Twenty-two of the 43 schools are experimenting with programmed instruction in only one subject area--mathematics. Almost all of these courses were using the TEMAC mathematics series. Ninety-one percent of the schools are involved with using programmed instruction without using machines; four or less subject areas are involved in these schools.

The fact that the TEMAC materials are used so much more widely than any other materials is of marked interest. One possible reason for this could be that the materials are designed to teach an entire course--materials are available for teaching a complete sequence of courses. This finding suggests that teachers are more likely to accept innovations that are planned for the total course rather than innovations that involve only a part of the course, even though the former has much more radical effects on their role. The key factor here may be the amount of teacher planning that is required. A total course of programmed materials including tests provides all of the materials and implies the existence of a complete organizational plan; in contrast, the use of a single program to teach a single concept may require more planning by the teacher to integrate the innovation into the course.

Table VI shows the number of schools and the number of courses in each school using language laboratories. For example, the second entry in the first column shows that 12 schools are using the language laboratories for three courses. The courses may be all in one subject area such as Spanish or in several subject areas such as Spanish and French. Sixty-seven schools were using language laboratories. Of the instructional innovations reported, the language laboratory

Appendix A (cont)

Table III. Number of Schools Using Programmed Instruction with Machines and Number of Courses in Which Innovation is Used

	Number of Schools	Number of Courses in which Innovation is Used
	4	1
	2	2
	1	4
	1	5
Total	8	12

Table IV. Number of Schools and Number of Courses in Each School Involved in the Use of Programmed Instruction Without Machines

	Number of Schools	Number of Courses in which Programmed Instruction is Used
	18	1
	5	2
	3	3
	9	4
	3	5
	1	7
	1	9
	1	10
	1	14
	1	15
Total	43	70

Appendix A (cont)

Table V. Number of Schools and Number of Subject Areas in Each School Involved in the Use of Programmed Instruction Without Machines

	Number of Schools	Number of Different Subject Areas Involved in Use of Programmed Instruction
	22	1
	8	2
	6	3
	3	4
	1	5
	1	6
	1	8
	1	9
Total	43	38

Appendix A (cont)

Table VI. Number of Schools and Number of Courses in Schools Using Language Laboratories

	Number of Schools	Number of Courses in Which a Language Laboratory is Used
	1	1
	12	3
	7	4
	2	5
	5	6
	3	7
	5	8
	7	9
	2	11
	12	12
	1	15
	8	16
	1	17
	1	20
Total	67	134

Appendix A (cont)

is by far the most frequently used. The 67 schools represent 83% of the schools that report being involved in any kind of an instructional innovation. The number of courses involved in the use of language laboratories in each school varies from 1 to 20. However, all of the courses are in foreign language. Table VII shows the number of schools and the number of subjects in each school using language laboratories. The majority of schools use the laboratories to teach four foreign languages.

Only four schools teach five languages. It is interesting to note that language laboratories are not being used for other kinds of instruction other than foreign language instruction. Contrary to what has often been reported, it was found that the language laboratories were much in use at the schools that were visited. Some schools reported that they wanted to use the laboratories for subjects other than language, but that there was no time on the machines available after they were scheduled for language instruction.

Table VIII shows the number of schools and the number of courses in each school using educational television (ETV). It is surprising that only 18 of the schools in the survey reported the use of ETV. Apparently the greatest use of this innovation is at the lower levels of instruction. Few courses using ETV are given at most of the schools, as shown in Table IX. The largest number of schools (seven) have only one subject in which ETV is used.

Table X shows the number of schools and the number of courses in each school that use closed-circuit television (CCTV). Only 12 schools reported the use of CCTV. The majority of these schools use CCTV in only a few courses. One school, however, reported use in 12 courses; another school reported use in 17 courses. Table XI shows that only nine subject areas are represented in the school with the highest frequency of use. Eight of the 12 schools are using CCTV in only one course. These findings are surprising, for when the cost of CCTV is considered, it would seem that a school would make more use of the innovation after making the investment. Perhaps the use is restricted because of the time and money required for production of programs. These data suggest that schools should be cautious before investing in CCTV systems.

D. ORGANIZATIONAL INNOVATION

Organizational changes are somewhat more difficult to define than instructional innovations using media. In this survey, any kind of a change from the traditional way of arranging students into classes with one teacher for an approximate hour of instruction was considered to be an organizational change. This definition included the following major types of innovation: continuous progress plans; nongraded and multiple track plans; and team teaching.

Appendix A (cont)

Table VII. Number of Schools and Number of Subject Areas Using Language Laboratories

Number of Schools	Number of Subject Areas Using Language Laboratories
10	1
15	2
22	3
16	4
4	5
Total 67	15

Table VIII. Number of Schools and Number of Courses Using Educational Television

Number of Schools	Number of Courses Using ETV
7	1
2	2
3	3
4	4
1	6
1	10
Total 18	26

Appendix A (cont)

Table IX. Number of Schools and Number of Subject Areas Using Educational Television

	Number of Schools	Number of Subjects Using ETV
	1	1
	3	2
	4	3
	3	4
	1	6
Total	12	16

Table X. Number of Schools and Number of Courses Using Closed-Circuit Television

	Number of Schools	Number of Courses Using CCTV
	5	1
	3	2
	1	3
	1	4
	1	12
	1	17
Total	12	39

Appendix A (cont)

Table XI. Number of Schools and Number of Subject Areas Using Closed-Circuit Television

Number of Schools	Number of Subject Areas Using CCTV
8	1
1	2
1	3
1	5
1	9
Total 12	20

Appendix A (cont)

Table XII shows the different number of schools using the three major kinds of organization change. Team teaching is the most common organizational innovation. In fact, this innovation is second in frequency only to the use of language laboratories. Three of the schools that reported use of the continuous progress plan stated that the entire schools were organized on a continuous progress plan basis. When site visits were made, however, it was found that these schools were only planning to put their courses on a continuous progress basis. In actuality, no school has been completely converted to a continuous progress plan. The two schools that have made the most progress in this direction are the Brigham Young University Laboratory School and Theodore High School. At the time of this writing, these schools have developed continuous progress courses in mathematics, English, science, typing, foreign language, and social studies. Nova High School has developed some courses that are organized on a continuous progress basis. The amount of effort required to make these changes is extensive and cannot be accomplished in a short time with the usual school resources.

Two of the schools that reported nongraded programs indicated that the total school was on a nongraded basis.

Table XIII shows the number of schools and the number of courses in each school using team teaching. Although the range of courses involved in any school is wide, the data indicate that the majority of schools presents only a few courses by this method. Again, these data suggest that the trend toward instructional innovation tends to be conservative. Most of the schools experiment with only a few courses. Three schools, Easton Joint High School, Buena Vista High School, and Nova High School operate almost entirely on a team basis, but they are by far the exception. Table XIV shows the number of schools and the number of subjects in each school using team teaching. Seventy-two percent of the 58 schools using team teaching involve only three or fewer subjects. The survey did not obtain extensive information on the kinds of team teaching that was in practice at the schools. The general descriptions that were obtained and the information gathered during the site visits indicated that the practices varied from school to school. The most common function found was group planning by two or three teachers who were responsible for a large group of students. In some cases, one teacher was designated as the head or master teacher. Sometimes the teachers divided the work by playing different roles such as presenter, discussion leader, materials writer, etc.; in other cases, the teachers shared the same roles on different occasions. In some schools teams were constructed across subject-matter lines--the most common examples were found in English and social studies. The usual procedure was to integrate the teaching of English with the teaching of social studies. The teachers would plan and work together so that the social studies teacher would give the students assignments to prepare reports relevant to the topics in social studies, and the English teacher would help the students with the preparation of the report. In most cases the teams came from the same subject areas.

Appendix A (cont)

Table XII. Organizational Innovations and the Number of Schools Using Each Type of Innovation

	Number of Schools	Organizational Innovations
	8	Ungraded Programs
	8	CPP
	58	Team Teaching
Total	74	

Table XIII. Number of Schools and Number of Courses Using Team Teaching

	Number of Schools	Number of Courses Using Team Teaching
	12	1
	5	2
	13	3
	9	4
	5	5
	3	6
	1	7
	2	8
	1	10
	1	12
	1	13
	1	16
	1	25
	3	whole school
Total	58	112 + whole school

Appendix A (cont)

Table XIV. Number of Schools and Number of Subject Areas Using Team Teaching

	Number of Schools	Number of Subject Areas Involving Team Teaching
	19	1
	9	2
	14	3
	6	4
	3	5
	1	7
	1	8
	1	9
	1	16
Total	55	55

Appendix A (cont)

E. EDUCATIONAL DATA PROCESSING

Table XV shows the number of schools using each of the different kinds of EDP applications. The most frequent application was in printing class rosters; the second most common application was in reporting grades. These applications, which are the most simple type possible, suggest that EDP will be used for more complex tasks only as experience is gained. The kinds of sophisticated innovation that are becoming possible in this area do not exist currently in any school, but there will probably be widespread use of computers in schools for complex functions within the next 10 years.

Table XVI shows the number of schools and the number of different functions in EDP at the various schools. Seven schools use EDP for five functions, six schools for six functions, and five schools for three functions. These data suggest that once EDP is installed or used, it tends to be used for multiple functions.

Appendix A (cont)

Table XV. Uses of Educational Data Processing in Innovative Schools

Number of Schools	Educational Data Processing Functions
26	Assign students to class schedule
13	Construct master schedule
33	Print class rosters
23	Attendance accounting
29	Grade reporting
25	Test scoring
10	Teaching of data processing

Table XVI. Number of Schools Using Educational Data Processing for Various Functions

	Number of Schools	Number of Different Functions Involved in EDP
	5	1
	3	2
	5	3
	13	4
	7	5
	6	6
Total	39	21

APPENDIX A

MATERIAL USED TO GATHER INFORMATION--
ATTACHMENTS 1 THROUGH 4

These four attachments present the material used to obtain information from schools:

Attachment 1--Introductory letter to the schools.

Attachment 2--List of schools to which questionnaires were sent.

Attachment 3--Instructions for completing the survey forms.

Attachment 4--Generalized trip plan when representatives interviewed personnel from innovating schools.

Appendix A, Attachment 1

July 17, 1963
L-13159

State Education Department
Officer Responsible for
Secondary Education

Dear Sir:

We have recently received a grant from the United States Office of Education to conduct research which involves system description and analysis and computer simulation of several high schools. Among the schools which we study, we want a limited number that are making extensive use of technological (e.g., language laboratories, programmed learning, television), methodological (e.g., team teaching), or organizational (e.g., Trump Plan) innovations. While we are aware of those schools that have received national publicity or that turn up recurrently on various lists, our feeling is that many schools may be conducting extensive experimentation with little publicity. For this reason, we are seeking to extend our inventory of such schools. We should greatly appreciate your help in this respect.

We have enclosed a self-addressed, air mail envelope and a form which we should like you to complete. On this form will you please list, for your state, those high schools that are making extensive use of innovations, and will you also answer the other questions about these schools. (We are not interested in schools that are employing only limited innovations such as a single language laboratory or team teaching in one content area.)

If, to your knowledge, no schools in your state are making broad use of innovations, would you please so indicate on the enclosed form and return it to us.

We appreciate your cooperation.

Sincerely yours,

/s/ Robert L. Egbert

Robert L. Egbert
Center for Research
in System Development

RLE:lk
Enclosures: 2

P.S.: If more forms are needed, please so indicate.

Appendix A, Attachment 1 (cont)

	Name and Address of School	Principal	Approximate Enrollment (Under 500; 500-1000; over 1000)	Tax Base (High, Medium, Low)	Type of Innovation (e.g., Trump Plan)
1.	Name ____ Address ____	____	____	____	____
2.	Name ____ Address ____	____	____	____	____
3.	Name ____ Address ____	____	____	____	____
4.	Name ____ Address ____	____	____	____	____
5.	Name ____ Address ____	____	____	____	____
6.	Name ____ Address ____	____	____	____	____
7.	Name ____ Address ____	____	____	____	____
8.	Name ____ Address ____	____	____	____	____

Appendix A, Attachment 2

ALABAMA

John Jackson, Principal
Theodore High School
Mobile County
Theodore, Alabama

ALASKA

(No schools making extensive use of innovations)

ARIZONA

William D. Lovett, Principal
Flowing Wells High School
3725 North Flowing Wells Road
Tucson, Arizona

John L. Tanner, Principal
Camelback High School
4612 North 28th Street
Phoenix, Arizona

ARKANSAS

M. O. Ramay, Principal
Hillcrest Junior High School
Fayetteville, Arkansas

Benny Winborn, Principal
Woodland Junior High School
Fayetteville, Arkansas

Herbert Lawrence, Principal
Jacksonville Junior High School
Jacksonville, Arkansas

Harold Smith, Principal
El Dorado High School
El Dorado, Arkansas

Austin White, Principal
Crossett High School
Crossett, Arkansas

ARKANSAS (cont)

Lee Cassady, Principal
Magnet Cove High School
Route 5
Malvern, Arkansas

H. V. Webb, Principal
Bald Knob Hill School
Bald Knob, Arkansas

Guy French, Superintendent
Weiner High School
Weiner, Arkansas

C. H. Geis, Superintendent
Jonesboro Junior High School
Jonesboro, Arkansas

CALIFORNIA

K. L. Peters, Superintendent
Beverly Hills Unified
255 South Lasky Drive
Beverly Hills, California

Edwin Kratt, Superintendent
Fresno Unified
2348 Mariposa Street
Fresno, California

James Dent, Superintendent
Mt. Diablo Unified
1936 Carlotta Drive
Concord, California

Stuart Phillips, Superintendent
Oakland Unified
1025 Second Avenue
Oakland 6, California

L. L. Jones, Superintendent
Ventura Union High School
295 South Arcade Drive
Ventura, California

Appendix A, Attachment 2 (cont)

CALIFORNIA (cont)

Paul Slauson, Superintendent
Covina Valley Unified
Post Office Box 269
Covina, California

A. L. Stevens, Jr., Superintendent
Fremont Union High School
Post Office Box 215
Sunnyvale, California

Harold Santes, Superintendent
Palo Alto Unified
25 Churchill Avenue
Palo Alto, California

Ralph Dailand, Superintendent
San Diego Unified
4100 Normal Street
San Diego 3, California

Nelson Price, Principal
Azusa High School
240 North Cerritas Avenue
Azusa, California

Gardner Swenson, Principal
Brookhurst Junior High School
123 North Citron Street
Anaheim, California

Ernest Payne, Principal
Chaffey High School
1245 North Euclid Avenue
Ontario, California

Harold Walker, Principal
Chemawa Junior High School
8830 Magnolia Avenue
Riverside, California

Lyle Martin, Principal
Claremont High School
Claremont, California

CALIFORNIA (cont)

Harold Allison, Principal
Drake High School
1327 Sir Francis Drake Blvd.
San Anselino, California

Keith Wood, Principal
Eastmont Junior High School
400 North Bradshaw Avenue
Montebello, California

Calvin Anderson, Principal
Palm Springs High School
2248 East Ramon Road
Palm Springs, California

COLORADO

Paul G. Grumley, Principal
Meeker High School
Post Office Box GG
Meeker, Colorado

Forbes Bottomly, Superintendent
Jefferson County Schools
(8 High Schools)
Post Office Box 15128
Lakewood, Colorado

CONNECTICUT

(No response to our requests)

DELAWARE

Henry R. Hoerner, Principal
Stanton Central Elementary
Stanton
Wilmington 4, Delaware

Edward L. Stephens, Principal
Forest Oak Elementary
Stanton
Wilmington 4, Delaware

Appendix A, Attachment 2 (cont)

DELAWARE (cont)

Dr. Thomas J. Jenkins, Principal
Brandywine High School
1400 Faulk Road
Wilmington 3, Delaware

Dr. Leroy C. Olson, Principal
Alfred I. duPont School District
1400 Faulk Road
Wilmington 3, Delaware

Dr. Kenneth C. Madden, Principal
Seaford Special School District
Seaford, Delaware

Mrs. Marguerite S. Benthall, Principal
Alexis I. duPont Special School District
Kennett Pike
Wilmington 6, Delaware

Gilmore B. Ott, Principal
Christiana High School
Newark, Delaware

FLORIDA

A. B. Wolfe, Principal
Nova School
Post Office Box 8369
Ft. Lauderdale, Florida

Dr. B. Frank Brown, Principal
Melbourne High School
Melbourne, Florida

Freeman H. Vaughn, Principal
Riverview High School
4850 Lords Avenue
Sarasota, Florida

Howard S. Fleming, Principal
Edgewater High School
3100 Edgewater Drive
Orlando, Florida

FLORIDA (cont)

John C. Gray, Principal
Martin County High School
500 East Ocean Blvd.
Stuart, Florida

Dr. Joe Hall, Superintendent
Dade County Schools
1410 N.E. Second Avenue
Miami, Florida

Ish Brant, Superintendent
Duval County Schools
508 Duval County Courthouse
Jacksonville 2, Florida

GEORGIA

Dr. John W. Letson, Superintendent
City Hall
Mitchell Street
Atlanta, Georgia 30303

Dr. Paul D. West, Superintendent
Fulton County Schools
500 Fulton County Administration Blvd.
Atlanta, Georgia 30303

Mr. Jim Cherry, Superintendent
DeKalb County Schools
DeKalb Building
Decatur, Georgia

Mr. William Henry Shaw, Superintendent
Muscogee County Schools
1200 Bradley Drive
Columbus, Georgia

Mr. D. Leon McCormac, Superintendent
Chatham County Schools
208 Bull Street
Savannah, Georgia

Appendix A, Attachment 2 (cont)

HAWAII

Stephen S. Kanda, Principal
Wallace R. Farrington High
1564 North King Street
Honolulu, Hawaii

IDAHO

(No extensive innovation programs)

ILLINOIS

(No response to our requests)

INDIANA

Walter Eiche, Principal
North Central High School
8401 Westfield Blvd.
Indianapolis, Indiana

George Bibich, Principal
Dyer Central High School
Joliet Street
Dyer, Indiana

John M. Houghland, Principal
Marion High School
520 West Nelson Street
Marion, Indiana

Frank H. Hammond, Superintendent
Munster Schools
8824 Columbia Avenue
Munster, Indiana

C. R. Erwin, Principal
Jeffersonville High School
601 East Court Avenue
Jeffersonville, Indiana

Delbert A. Brown, Principal
New Albany High School
1020 Vincennes Street
New Albany, Indiana

INDIANA (cont)

Adrian L. Meadows, Principal
North High School
2319 Stringtown Road
Evansville, Indiana

Paul Dunker, Principal
Rockport High School
South Fifth Street
Rockport, Indiana

IOWA

Dr. William Anderson, Principal
Cedar Falls Community Schools
9th and Washington
Cedar Falls, Iowa

Dr. John Harris, Principal
Des Moines Community Schools
1800 Grand Avenue
Des Moines, Iowa

Perley O. Brunsvold, Principal
Mason City Community Schools
120 East State Street
Mason City, Iowa

Dr. Arnold Salisbury, Principal
Cedar Rapids Community Schools
346 - 2nd Avenue
Cedar Rapids, Iowa

Dr. William L. Little, Principal
Fort Madison Community Schools
20th and B Streets
Fort Madison, Iowa

Carl T. Feelhaven, Principal
Fort Dodge Community Schools
5th North 16th Street
Fort Dodge, Iowa

Appendix A, Attachment 2 (cont)

KANSAS

(No extensive innovation programs)

KENTUCKY

Don Ralings, Principal
Danville High School
Danville, Kentucky

Clyde T. Tassiter, Principal
Henry Clay High School
East Main Street
Lexington, Kentucky

H. L. Ellis, Principal
Ashland High School
Ashland, Kentucky

Kenneth Farmer, Principal
Seneca High School
1310 Goldsmith Lane
Louisville, Kentucky

Earl Duncan, Principal
Waggener High School
330 South Hubbard Lane
Louisville, Kentucky

J. C. Cantrill, Principal
Valley High School
Dixie Highway
Valley Station, Kentucky

Russell Garth, Principal
Atherton High School
3000 Dundee Road
Louisville, Kentucky

Bro. Edward Daniel, C.F.X.
St. Xavier High School
1609 Poplar Level Road
Louisville, Kentucky

LOUISIANA

(No response to our requests)

MAINE

Orono High School
Orono, Maine

Westbrook High School
Westbrook, Maine

MARYLAND

Dr. George B. Brain
Superintendent of Schools
Baltimore Public Schools
3 East Twenty-Fifth Street
Baltimore, Maryland 21218

Mr. William S. Sartorius
Superintendent of Schools
Baltimore County Board of Education
Aigburth Manor
Towson 4, Maryland

Mr. Maurice A. Dunkle
Superintendent of Schools
Calvert County Board of Education
Dares Beach Road
Prince Frederick, Maryland

Dr. James A. Sensenbaugh
Superintendent of Schools
Frederick County Board of Education
115 East Church Street
Frederick, Maryland

Dr. C. Taylor Whittier
Superintendent of Schools
Montgomery County Board of Education
850 North Washington Street
Rockville, Maryland

Appendix A, Attachment 2 (cont)

MARYLAND (cont)

Dr. William M. Brish
Superintendent of Schools
Washington County Board of Education
Commonwealth Avenue
Hagerstown, Maryland

MASSACHUSETTS

William J. Gallaher, Principal
Waltham High School
Waltham, Massachusetts

Walter K. Hjelm, Principal
Braintree High School
Braintree, Massachusetts

Raymond J. Montagna, Principal
Springfield Classical High School
Springfield, Massachusetts

Paul A. Farris, Principal
Hingham High School
Hingham, Massachusetts

John T. Conrad, Principal
Chelmsford High School
Chelmsford, Massachusetts

John Donovan, Principal
Condord-Carlisle Regular High School
Condord, Massachusetts

Raymond Hettler, Principal
Wayland High School
Wayland, Massachusetts

MICHIGAN

Schools recommended by Samuel Miller Brownell:

Henry Ford School) Detroit
Eastern High School)

Edwin Denby High School

MICHIGAN (cont)

Michigan Schools recommended by:
Nicholas P. Georgiady, Asst. Supt.,
but information not available until
latter part of year:

Nicholas Schreiber, Principal
Ann Arbor High School
1220 Wells
Ann Arbor, Michigan

Jay W. Formsma, Principal
Holland High School
340 Pine Avenue
Holland, Michigan

Theodore B. Southerland, Principal
Bay City Central High School
1624 Columbus Avenue
Bay City, Michigan

Alden Bierman, Principal
Benton Harbor High School
870 Colfax
Benton Harbor, Michigan

Refer to Supt. Dr. Samuel Brownell
Detroit Public Schools
1354 Broadway
Detroit, Michigan

Robert L. Blue, Principal
Buena Vista High School
3945 Holland Road
Saginaw, Michigan

Anthony J. Lawski, Principal
Edsel Ford High School
20601 Rotunda
Dearborn, Michigan

John E. Wellington, Principal
Holt High School
4252 East Delhi
Holt, Michigan

Appendix A, Attachment 2 (cont)

MICHIGAN (cont)

John Brandt Smith, Principal
Charlotte High School
Charlotte, Michigan

Refer to Supt. Lawrence L. Jarvie
Flint Public Schools
923 East Kearsley
Flint, Michigan

Robert Baston, Principal
Harbor Beach High School
402 South 5th Street
Harbor Beach, Michigan

M. Barrett Vorce, Principal
Lee M. Thurston High School
26255 Schoolcraft Road
Detroit, Michigan

Jack Adams, Principal
Lamphere High School
610 West 13 Mile Road
Madison Heights, Michigan

William Wang, Principal
Midland High School
1301 Eastlawn Drive
Midland, Michigan

Murel G. Burdick, Principal
Muskegon High School
80 West Southern Avenue
Muskegon, Michigan

MINNESOTA

Russell D. Brackett, Principal
Ramsey Junior High School
Nicollet and West 49th
Minneapolis 9, Minnesota

MINNESOTA (cont)

Milo Mielke, Principal
Robbinsdale Senior High School
Robbinsdale, Minnesota

Stanley H. Gustafson, Principal
Sibley High School
West St. Paul, Minnesota

Curtis Johnson, Principal
Ramsey Senior High
Roseville
Minneapolis 13, Minnesota

Roy Isaacsen, Principal
Como Junior High School
St. Paul, Minnesota

Fred M. King
Director of Instruction
Rochester Schools
Rochester, Minnesota

MISSISSIPPI

(No extensive innovation programs)

MISSOURI

Richard F. Stauffer, Principal
Horton Watkins High School
1201 South Warson Road
Ladue 24, Missouri

C. E. Potter, Principal
Normandy Senior High School
6701 Easton Avenue
St. Louis 33, Missouri

James A. Hazlett, Superintendent
Kansas City Public Schools
1211 McGee Street
Kansas City 6, Missouri

Appendix A, Attachment 2 (cont)

MONTANA

(No extensive innovation programs)

NEBRASKA

Kenneth Hansen, Principal
Westside Community High School
Omaha, Nebraska

Richard Sedlacek, Principal
Crete Public Schools
Crete, Nebraska

William Bogar, Principal
Lincoln Central High School
Lincoln, Nebraska

Frank Bressler, Principal
Minden Public Schools
Minden, Nebraska

NEVADA

(No extensive innovation programs)

NEW HAMPSHIRE

(Refer to Educational Directory)

NEW JERSEY

Eugene H. Van Vleit, Principal
Tenafly High School
1 West Forest Avenue
West Englewood, New Jersey

William W. Rogers, Principal
Madison High School
Ridgedale Avenue
Madison, New Jersey

NEW JERSEY (cont)

D. L. Peterson, Principal
Mountain Lakes High School
Powerville Road
Mountain Lakes, New Jersey

William C. Leach, Principal
Ridgewood High School
Educational Center
49 Cottage Place
Ridgewood, New Jersey

NEW MEXICO

(No extensive innovation programs)

NEW YORK

State Education Department did not answer our request. However, see last page for schools recommended by Lester W. Nelson, The Fund for Advancement of Education.

NORTH CAROLINA

(No extensive innovation programs)

NORTH DAKOTA

(No extensive innovation programs)

OHIO

Calvin Moore, Principal
Nordonia
Northfield, Ohio

Mahlon Povenmire, Principal
Lakewood
Lakewood, Ohio

Appendix A, Attachment 2 (cont)

OHIO (cont)

Keith Williams, Principal
West Clermont
Amelia, Ohio

Thomas Gallant, Principal
Huron
Huron, Ohio

M. H. Robb, Principal
Central Junior High School
1520 Chardon Road
Euclid, Ohio

OKLAHOMA

C. B. Breithaupt, Principal
Capitol Hill High School
Oklahoma City, Oklahoma

J. H. Lawter, Principal
Central High School
Oklahoma City, Oklahoma

J. Garwin Fleming, Principal
Classen High School
Oklahoma City, Oklahoma

O. M. McDaniels, Principal
Douglass High School
Oklahoma City, Oklahoma

Clarence Huffman, Principal
U. S. Grant High School
Oklahoma City, Oklahoma

Darrell McFeaters, Principal
Harding High School
Oklahoma City, Oklahoma

Robert B. Cheney, Principal
John Marshall High School
Oklahoma City, Oklahoma

OKLAHOMA (cont)

Lester Reed, Principal
Northeast High School
Oklahoma City, Oklahoma

F. Frank Malone, Principal
Northwest Classen High School
Oklahoma City, Oklahoma

Lederle J. Scott, Principal
Southeast High School
Oklahoma City, Oklahoma

A. R. Reeder, Principal
Star-Spencer High School
Oklahoma City, Oklahoma

Frank Malone, Principal
North West High School
N.W. 27 and May
Oklahoma City, Oklahoma

Gene Hancock, Principal
Lawton High School
Lawton, Oklahoma

Ray L. Polk, Principal
Mid-West City High School
Mid-West City, Oklahoma

Donald Rymer, Principal
Choctaw High School
Chocktaw, Oklahoma

Lewis Bean, Principal
Pawhuska High School
Pawhuska, Oklahoma

Fred Kelton, Principal
Miami High School
Miami, Oklahoma

Appendix A, Attachment 2 (cont)

OREGON

Dr. Gaynor Petrequin, Principal
Marshall High School
3905 SE 91st Avenue
Portland 66, Oregon

Dr. Kenneth A. Erickson, Principal
Wilson High School
1151 SW Vermont
Portland 19, Oregon

Don W. James, Principal
Roosevelt High School
6941 North Central
Portland 3, Oregon

Ray Talbert, Principal (next year)
Bend High School
Bend, Oregon

Roger Dasch, Principal
Stayton High School
Stayton, Oregon

Wayne Flynn, Principal
Sheldon High School
Eugene, Oregon

Lester Harris, Principal
Medford High School
Medford, Oregon

Robert Daggett, Principal
David Douglas High School
1500 SE 130th Avenue
Portland 33, Oregon

PENNSYLVANIA

Dr. Allen Wetter, Superintendent
Philadelphia School District
Parkway at 29th Street
Philadelphia, Pennsylvania

PENNSYLVANIA (cont)

Dr. Edward Tracy, Superintendent
Easton Area Joint High School
Easton, Pennsylvania

Dr. Fred Bryan, Superintendent
Harrisburg City School District
Harrisburg, Pennsylvania

Dale W. Smith, Supervising Principal
West Shore Joint Schools
Lemoyne, Pennsylvania

RHODE ISLAND

(No extensive innovation programs)

SOUTH CAROLINA

Dr. Jack B. Boger, Principal
Winthrop Training School
Rock Hill, South Carolina

J. K. Blum, Principal
A. C. Flora High School
Columbia, South Carolina

SOUTH DAKOTA

Ben O. Rossow, Principal
Sioux Falls Public Schools
Sioux Falls, South Dakota

TENNESSEE

(Refer to Bulletin listing schools for additional information)

Dave F. Adkisson, Superintendent
Bristol City Schools
Bristol, Tennessee

Appendix A, Attachment 2 (cont)

TENNESSEE (cont)

W. H. Oliver, Superintendent
Nashville City Schools
Nashville, Tennessee

J. E. Moss, Superintendent
Davidson County Schools
Nashville, Tennessee

E. C. Stimbert, Superintendent
Memphis City Schools
Memphis, Tennessee

R. M. Robinson, Superintendent
Alcoa City Schools
Alcoa, Tennessee

Bennie Carmichael, Superintendent
Chattanooga City Schools
Chattanooga, Tennessee

Thomas N. Johnston, Superintendent
Knoxville City Schools
Knoxville, Tennessee

TEXAS

John F. Smith, Principal
Big Spring High School
Big Spring, Texas

Minton White, Principal
Central High School
San Angelo, Texas

Lipscomb Anderson, Principal
Austin High School
Austin, Texas

John Gibens, Principal
Robert E. Lee Jr. High School
San Angelo, Texas

TEXAS (cont)

Ross Larsen, Principal
Amarillo High School
Amarillo, Texas

George L. Morton, Principal
South Park High School
Pasadena, Texas

John Grace, Superintendent
Texas School for the Deaf
Austin, Texas

Kenneth Wilson, Principal
Brazosport High School
Freeport, Texas

Clyde Gott, Principal
Thomas Jefferson High School
Port Arthur, Texas

Vernon C. Payne, Principal
Andrews Junior High School
Andrews, Texas

J. J. Pearce, Superintendent
Richardson ISD
Richardson, Texas

Thomas Hartman, Headmaster
St. Marks School
Dallas, Texas

Morgan Evans, Superintendent
Galveston ISD
Galveston, Texas

John McFarland, Superintendent
Houston ISD
Houston, Texas

Appendix A, Attachment 2 (cont)

TEXAS (cont)

Glenn Littrell
Corpus Christi ISD
Corpus Christi, Texas

Herbert Overfield, Principal
Robert E. Lee Elementary
Austin, Texas

M. G. Bowden, Principal
Casis Elementary School
Austin, Texas

UTAH

Cedar City Senior High School
Cedar City, Utah

Weber County

VERMONT

(No extensive programs)

VIRGINIA

Mr. Ray E. Reid, Superintendent
Arlington County Schools
1426 North Quincy Street
Arlington 10, Virginia

Dr. E. W. Rushton, Superintendent
Roanoke City Schools
Roanoke, Virginia

Mr. H. I. Willett, Superintendent
Richmond City Schools
312 North Ninth Street
Richmond 19, Virginia

Mr. Edwin W. Chittum, Superintendent
Chesapeake City Schools
2313 Cedar Road
Great Bridge
Chesapeake, Virginia

WASHINGTON

Bellevue School District No. 405
310-102nd Avenue N.E.
Bellevue, Washington

Highline School District No. 401
253 South 152nd Street
Seattle 88, Washington

Seattle School District No. 1
815 - 4th Avenue North
Seattle 9, Washington

Shoreline School District No. 412
N.E. 158th and 20th N.E.
Seattle 55, Washington

Spokane School District No. 81
West 825 Trent
Spokane, Washington

Richland School District No. 400
Richland, Washington

Tacoma School District No. 10
Post Office Box 1357
Tacoma 1, Washington

Vancouver School District No. 37
605 North Devine Road
Vancouver, Washington

WEST VIRGINIA

Marvin Lee, Principal
South Charleston High School
South Charleston, West Virginia

Rexford Plymale, Principal
Charleston High School
Charleston, West Virginia

Appendix A, Attachment 2 (cont)

WEST VIRGINIA (cont)

David Hypes, Principal
Fayetteville High School
Fayetteville, West Virginia

Ralph Hixenbaugh, Principal
East Bank High School
East Bank, West Virginia

Crawford Cameron, Principal
Weir High School
Weirton, West Virginia

Raymond Arbogast, Principal
Nitro High School
Nitro, West Virginia

Grant Nine, Principal
University High School
Morgantown, West Virginia

WISCONSIN

Clifford L. O'Bierne, Principal
Hayward Public Schools
Hayward, Wisconsin

R. O. Bonske, Principal
Franklyn Elementary Schools
8222 - 51st Street
Milwaukee, Wisconsin

Russell E. Harris, Principal
Racine Junior High School
Racine, Wisconsin

Rob L. Shanks, Principal
Janesville Public Schools
315 South Jackson Street
Janesville, Wisconsin

Tom Linton, Principal
Milwaukee Public Schools
5225 Vliet Street
Milwaukee, Wisconsin

WISCONSIN (cont)

Marshall R. Taylor, Principal
Wausau High School
515 Scott Street
Wausau, Wisconsin

John F. David, Principal
Preble High School
Preble, Wisconsin

Dr. Alan Slagle, Principal
Manitowoc Public Schools
15145 - 4th Street
Manitowoc, Wisconsin

Arthur Weiner, Principal
West Bend High School
West Bend, Wisconsin

WYOMING

Grant Goodrich, Principal
Lovell Public Schools
Lovell, Wyoming

William Reese, Principal
Casper Schools and High School
Casper, Wyoming

J. K. Cabett, Superintendent
Vern Newman, Principal
Laramie Public Schools
Laramie Wyoming

Dr. Willard Jones, Principal
University of Wyoming
University Schools
Laramie, Wyoming

Appendix A, Attachment 2 (cont)

Schools suggested by Leston W. Nelson which have innovating practices and programs in operation:

Glenbrook South High School
Glenview, Illinois

McPherson High School
McPherson, Kansas

Newton South High School
Newton, Massachusetts

Weston High School
Weston, Massachusetts

Eugene High School
Eugene, Oregon

Mr. Eugene R. Howard
Ridgewood High School
Norridge, Chicago 31, Illinois

Mr. Lloyd S. Michael
Evanston Township High School
Evanston, Illinois

Mr. Kenneth W. Lund
Oak Park-River Forest High School
Oak Park, Illinois

Mr. Lester J. Grant
Decatur School System
Decatur, Illinois

Mr. William H. Cornog
New Trier Township High School
Winnetak, Illinois

Principal
Pioneer High School
Palo Alto, California

Dr. Everett A. McDonald
Centennial Joint Schools
Street & Newtown Roads
Johnsville, Pennsylvania

Brother Cassian, F.S.C.
De La Salle High School
5300 St. Charles Avenue
New Orleans, Louisiana

Brother A. Francis, F.S.C.
St. Paul's High School
P. O. Box 149
Covington, Louisiana

Mr. J. R. Gormley, Principal
De Ridder High School
De Ridder, Louisiana

Mr. J. E. Turner, Principal
Woodlawn High School
7340 Wingate Avenue
Shreveport, Louisiana

Mr. J. S. Nicosia, Principal
Lake Charles High School
1509 Enterprise Boulevard
Lake Charles, Louisiana

Mr. Ellis A. Brown, Principal
Istrouma High School
3730 Winbourne Avenue
Baton Rouge, Louisiana

Mr. R. G. Markham, Principal
Natchitoches High School
Natchitoches, Louisiana

Appendix A, Attachment 2 (cont)

Mr. E. J. Garland, Jr., Principal
Nicholls High School
3820 St. Claude Avenue
New Orleans, Louisiana

Bryce Perkins, Program Director

Brian McMahon School
Norwalk, Connecticut

Mr. J. B. Smith, Program Director
Greenwich High School
Greenwich, Connecticut

Miss Helen Patterson, Program Director
Norwalk School System
Norwalk, Connecticut

Mr. Alfred LaMarche, Program Director
Norwalk School System
Norwalk, Connecticut

Mr. Norton Rhoades, Program Director
Rippowam School
Stamford, Connecticut

Mr. Enda Riordan, Program Director
Rippowam School
Stamford, Connecticut

Mr. Donald W. Fowler, Program Director
Bunnell, Stratford Schools
Stratford, Connecticut

Mr. Arthur Gibney, Program Director
Elmwood School
West Hartford, Connecticut

Appendix A, Attachment 3

Instructions for Completing

Educational Innovation Survey Forms

Four forms (HSSP-1, HSSP-2, HSSP-3, and HSSP-4) are supplied for your use. Two of the forms are provided to obtain information about the educational innovations that you currently are using. And, the other two forms are provided to obtain information about educational innovations that you are planning for the future.

On form HSSP-1, "Innovations in Use," you are to list in the appropriate spaces the names of the courses in which you are using the innovation. Notice that the different kinds of innovations are listed on the left.

If you are using any of the innovations listed, you are to fill in the names of the courses in the appropriate spaces to the right of each kind of innovation. In order to simplify the task of analysis, please use the following conventions when listing the courses. First, write the name of the course, such as English, History or Math. Following the name of the course, write the number of the grade level 10, 11, or 12. Finally, write a slash and indicate the number of semesters that you have used the innovation in the course. For example, if you are using English 2600, a comercially produced program in English grammer, in one or some of your 10th-grade English classes, and this is the first semester that you have tried the innovation, you would write: English 10/1 in the form as follows:

2. Programmed Learning without Teaching Machines	English 10/1	____________
	____________	____________
	____________	____________

On form HSSP-2, "Descriptions of Innovations in Use," briefly describe the innovations that you are using in the appropriate spaces. If the materials or programs you are using are commercially produced, provide the trade name. If the materials are produced locally and are experimental, provide a very brief description. Your major objective in filling out this form should be to provide a more accurate picture of what you are using and the way in which you are using it.

Forms HSSP-3 and HSSP-4 are identical to form HSSP-1 and HSSP-2, except for the headings. On these forms you are to list the names of the courses in which you are planning innovations. Obviously, you will not list the number

Appendix A, Attachment 3 (cont)

of semesters that you have used the innovation. In place of the number of semesters that you have used the innovation, please indicate the year that you predict you will use the innovation. In other words, if you are planning to use a weekly Educational TV program in science at the eleven year level in 1964, you will write in one of the spaces to the right of Educational TV on form HSSP-3: Science 11/1964.

If you are planning to continue the innovations that you listed and described as "in use," please do not list these again on forms HSSP-3 and HSSP-4. We are only interested in learning about the plans you have for the use of new innovations that you aren't currently using.

If you are using or planning to use educational innovations other than those listed in the left hand column, please describe them in the space provided which is labeled "11: other."

Please return the completed forms to:

Dr. John F. Cogswell
System Development Corporation
2500 Colorado Avenue
Santa Monica, California

Appendix A, Attachment 3 (cont)

INNOVATIONS IN USE
(Form HSSP-1)

INNOVATIONS	Courses and Number of Months in Use		
1. Teaching Machines with Programmed Learning			
2. Programmed Learning without Teaching Machines			
3. Educational TV			
4. Closed-Circuit TV			
5. Language Laboratory			
6. Flexible Scheduling			

Appendix A, Attachment 3 (cont)

INNOVATIONS IN USE (cont)
(Form HSSP-1)

Innovations	Courses and Number of Months in Use		
7. Ungraded Program	____	____	____
	____	____	____
	____	____	____
8. Team Teaching	____	____	____
	____	____	____
	____	____	____
9. Continuous Progress Plan	____	____	____
	____	____	____
	____	____	____
10. Electronic Data Processing	(If these innovations are being used for the whole school or a major part of the school, please note this fact rather than listing all of the courses.)		
(a) Scheduling--class loading and assignment	____		
(b) Scheduling--constructing master schedule	____		
(c) Scheduling--printing class cards, rosters, etc.	____		

Appendix A, Attachment 3 (cont)

INNOVATIONS IN USE (cont)
(Form HSSP-1)

Innovations	Courses and Number of Months in Use
10. Electronic Data Processing (cont)	
(d) Attendance accounting	
(e) Grade reports	
(f) Test scoring and analysis	
(g) Courses in electronic data processing	
(h) Kind of computer equipment (if you have a computer available, please name the computer.)	
11. Other	

Appendix A, Attachment 3 (cont)

DESCRIPTIONS OF INNOVATIONS IN USE
(Form HSSP-2)

1. Teaching Machines with Programmed Learning__________

2. Programmed Learning__________

3. Educational TV__________

4. Closed-Circuit TV__________

5. Language Laboratories__________

Appendix A, Attachment 3 (cont)

DESCRIPTIONS OF INNOVATIONS IN USE (cont)
(Form HSSP-2)

6. Flexible Scheduling ____________________

7. Ungraded Program ____________________

8. Team Teaching ____________________

9. Continuous Progress Plan ____________________

Appendix A, Attachment 3 (cont)

DESCRIPTIONS OF INNOVATIONS IN USE (cont)
(Form HSSP-2)

10. Electronic Data Processing

11. Other

Appendix A, Attachment 3 (cont)

INNOVATIONS PLANNED
(Form HSSP-3)

Innovations			
1. Teaching Machines with Programmed Learning			
2. Programmed Learning without Teaching Machines			
3. Educational TV			
4. Closed-Circuit TV			
5. Language Laboratory			
6. Flexible Scheduling			

Appendix A, Attachment 3 (cont)

INNOVATIONS PLANNED (cont)
(Form HSSP-3)

Innovations			
7. Ungraded Program	________	________	________
	________	________	________
	________	________	________
8. Team Teaching	________	________	________
	________	________	________
	________	________	________
9. Continuous Progress Plan	________	________	________
	________	________	________
	________	________	________

10. Electronic Data Processing

(If these innovations are being used for the whole school or a major part of the school, please note this fact rather than listing all of the courses.)

(a) Scheduling--class loading and assignment ______________________

(b) Scheduling--constructing master schedule ______________________

(c) Scheduling--printing class cards, rosters, etc. ______________________

Appendix A, Attachment 3 (cont)

INNOVATIONS PLANNED (cont)
(Form HSSP-3)

Innovations

10. Electronic Data Processing (cont)
   - (d) Attendance accounting ____________________
   - (e) Grade reports ____________________
   - (f) Test scoring and analysis ____________________
   - (g) Courses in electronic data processing ____________________
   - (h) Kind of computer equipment (if you have a computer available, please name the computer.) ____________________

11. Other ____________________

Appendix A, Attachment 3 (cont)

DESCRIPTIONS OF INNOVATIONS PLANNED
(Form HSSP-4)

1. Teaching Machines with Programmed Learning ____________

2. Programmed Learning ____________

3. Educational TV ____________

4. Closed-Circuit TV ____________

5. Language Laboratories ____________

Appendix A, Attachment 3 (cont)

DESCRIPTIONS OF INNOVATIONS PLANNED (cont)
(Form HSSP-4)

6. Flexible Scheduling

7. Ungraded Program

8. Team Teaching

9. Continuous Progress Plan

Appendix A, Attachment 3 (cont)

DESCRIPTIONS OF INNOVATIONS PLANNED (cont)
(Form HSSP-4)

10. Electronic Data Processing

11. Other

Appendix A, Attachment 4

INNOVATING SCHOOLS' TRIP PLAN

(Outline)

I. Briefing of principal

A. Purpose of project

B. Purpose of this visit

1. Describe project to school personnel
2. Obtain information about the school
3. Determine whether school would participate if asked

C. Possible benefits to school

1. Detailed analysis may prove useful
2. Could lead to joint proposals

D. Statement of what we expect from participating school

1. Extensive interviews with such key people as the principal, head counselor, data processing supervisor, AVA director, and head teachers
2. Detailed student information, e.g., intelligence and achievement test scores, grades, and registration

II. Obtain information

A. Philosophical position--why innovating

B. Detailed information on items described on pp. 2 and 3 of "Visit to Schools" document and Forms A and C of "School Survey Questionnaire"

Appendix A, Attachment 4 (cont)

VISIT TO SCHOOLS

Arrangements with Schools for Visit

1. Principal and/or superintendent should be contacted by letter or by telephone if time is limited.

2. High priority schools should be visited for a whole day. Lower priority schools should be visited for a half-day.

3. Arrangements should be made to spend time with the key administrative persons and with the people in the school who are involved in the innovation.

4. Administrative personnel should be informed that the visit reflects our interest in seeing what they are doing, but that the visit does not indicate a commitment to the school for inclusion in the simulation project.

5. An effort should be made to assess the school's willingness to participate in the program. We should also make this evaluation with an eye to the future. We should have some feeling for the school's interest in becoming involved in follow-up or continuation studies and proposals.

6. A school's interest in participating with us will depend upon their perception of what may accrue to them. Therefore, we should be prepared to point out the following:

   a. The detailed analysis may provide information of decided use for their planning.

   b. The effort could lead to joint proposals for support of follow-on studies.

7. Schools will probably also want to know what their involvement will be. We should tell them that we will need to spend approximately two weeks in interviewing their principal, head counselor, data processing supervisor, and head teachers. We may also want to interview other key people. We should make clear the distinction between a systems analysis and an evaluation survey. We will not evaluate people. We will analyze the system including trying to suggest various modifications that may be tested on the computer using the simulation vehicle.

Appendix A, Attachment 4 (cont)

VISIT TO SCHOOLS (cont)

8. We should check with John Coulson to make certain that our visits are coordinated with any visits or arrangements made in relation to the "Traveling Seminar."

Data Collection

The orientation of project personnel in visiting the schools should be to acquire a descriptive understanding of the innovations in the school that would withstand detailed questioning by the other project members. At this stage we will not collect data in a quantitative format with ratings, etc. But we must collect data at a fine descriptive level so that we can make meaningful comparisons between the schools.

We will first need to obtain a statement of the major philosophical position adopted by the school and the relationship of innovation to these goals and ideals. In other words, we will, in effect, ask the school personnel "Why are you innovating?"

Our next step will be to get such detailed information as the following:

Programmed Instruction

Description
How used
- In class?
- Role of teacher?
- All students?
- Percent of instruction?
- Variation in use?
- Relation to other aspects of the course?
- Is this an established procedure or a trial?

What are the most pressing problems with the innovation?

Flexible Scheduling

Describe schedule
- --in terms of blocks
- --choices by teachers
- --frequency of changes
- --student freedom of choice
- --use of space

Appendix A, Attachment 4 (cont)

VISIT TO SCHOOLS (cont)

Team Teaching

Arrangement
Role of teachers
--Percent time in planning
--What roles
--How many
Flexibility versus rigidity
Kind of space associated with each activity

We will need to gather such information as this for each of the innovations suggested on the original questionnaire.

The innovations suggested on the original questionnaire on which we will gather detailed information are:

Programmed Instruction (Machine)
Programmed Instruction
Educational Television
Closed-Circuit Television
Language Laboratories
Other

- -

Ungraded School
Continuous Progress School
Team Teaching
Other

- -

Schedule Assignments (CLASS)
Construct Schedule
Print Rosters
Attendance Accounting
Grade Reporting
Test Scoring
Courses in Educational Data Processing

- -

APPENDIX B

COMPUTER SIMULATION CAPABILITY

(EDSIM)

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Appendix B

A. INTRODUCTION

This appendix describes EDSIM, the computer simulation capability, that was developed for the project. Section B provides a description for the reader who is not sophisticated in computer programming. Sections C-F present a technical description for technical persons who might be interested in either using the programs or in developing a similar capability. Section G discusses plans for the future and is addressed to both the technical and nontechnical readers.

B. GENERAL DESCRIPTION OF THE SIMULATION CAPABILITY

1. Objectives

One of the primary objectives of the project was to explore the use of computer simulation for the organizational planning that is required to implement instructional innovations. The intent was to develop a capability for simulating the plans of school planners for organizing instructional resources. Thus the following specific objectives were formulated:

- The simulation capability should provide the means for constructing models of either existing or proposed plans for organizing instructional resources.
- The procedures must allow for easy modification of the models to represent alternative design configurations.
- Procedures must allow for the representation of dynamic events, i.e., changes that occur through time.
- Procedures must provide for detailed recording and meaningful summarization of the events that are simulated.
- Communication procedures for inserting descriptive variables for defining a model and for retrieving output information should be oriented to users who are not trained in computer programming.
- Procedures should be developed for simulating the activities of individual students and for organizing students into groups.

Appendix B (cont)

2. Procedures Used to Develop the Simulation Capability

A strategy for determining what variables, events, and procedures the simulation vehicle should be capable of representing was developed for the project. It was decided that the system descriptions and analyses of the five schools described in Appendixes C through G would be studied and that the simulation capability would be developed to represent the procedures in the five schools. The rationale for this strategy was that if a general capability for constructing models related to five different schools was developed, the capability should have further applicability to many other kinds of schools. Also, it was decided that if the simulation capability was to have any utility it should be designed as a tool for helping persons involved in the task of trying to analyze real instructional systems. The first formal definition of the simulation capability was reported in Reference 10. The system analysis effort at that time was concerned with the study of the continuous progress plan at Brigham Young University, and described and analyzed the total school operation. Logical procedures were developed for constructing models of students going through admission procedures, counseling procedures, instructional procedures, and termination procedures.

As the study progressed, greater definition of the project focus and procedures occurred. The system analyses conducted of Nova High School, Buena Vista High School, Theodore High school, and Garber High School were focused primarily on the procedures within the instructional part of the system rather than on procedures in counseling, admissions, etc. Nearly all of these studies concentrated on developing a system description and analysis of a specific innovating course in each of the schools. This delineation in the focus of the project led to concentrated development of procedures for simulating procedures in the instructional operation of courses.

3. Characteristics of Instructional Systems that can be Modeled

The simulation capability that was developed in the project conforms to the specific objectives described above. It provides the capability of constructing models of instructional plans that are expressed as follows:

- Definition of a population of students that may vary in size. For most of the models that were developed in the project, 100 students were defined for each course.

- Descriptions of classes of students. Students can be characterized as individuals by defining them as members of a descriptive class. A number of the models that were developed characterized students as belonging to one of three classes--fast, medium, and slow. A rate of progress for the student is related to each of these classes.

Appendix B (cont)

- Definition of activities. An activity is a computer process which represents a specific task defined by the model. As many as 60 activities can be defined for any one model. An activity can be labeled appropriately in the model so that output listings are in terms of the function of the activity. For example, activities like individual study and group help can be labeled in the model of a continuous progress plan; large group instruction and small group work can be labeled in the simulation of a team teaching course.

- The length of time that students spend in activities can be varied.

- Determination of which activity will be selected next in a sequence for an individual student or group of students, based upon probabilities that are associated with different classes of students. For example, slow students can be given a high probability that they will need help from the teacher frequently. Likewise, students may take more than one course; one model simulated 100 students taking five different courses. Another model simulated six classes of students going through six years of course work in mathematics.

- Description of models by input cards that define the names of activities, their length of duration, their sequence, and the rules for sequencing different kinds of students.

A detailed recording of each student's history in the course is made for each simulated model. Output summaries are produced by another set of programs that select and organize categories of data from the detailed recording. Some of the output summaries are as follows:

- Summary of the total number of times students have been through each activity in the model for any defined segment of time. For example, 82 fast students went through individual study.

- Summary of the total student time that was charged to an activity. For example, 168 students spent a total of 840 cycles in group help, or five cycles per person.

- Frequency distributions of the number of times that various events occur in the model. For example, five fast students were in group help twice, three fast students were in group help four times, etc.

The various models that were constructed and the various uses of the models are described in Appendixes C-G.

Appendix B (cont)

C. THE PROGRAMMING LANGUAGE

A number of computer languages have been developed in recent years. These languages are specifically oriented to simulation studies. Among these are SIMSCRIPT, SIMPAC, and GPSS. None of these simulation languages were used for the following reasons: First, a large programming effort would be required to implement any of those languages on the computers which would be available to us; in addition, we would have to educate ourselves in their utility. Second, it was felt that the advantage of these simulation languages over any problem-oriented language such as JOVIAL was not worth the extra effort and time. JOVIAL provides many of the capabilities provided in the specified simulation languages. In addition, the language is used widely throughout System Development Corporation; therefore, system development and maintenance of the JOVIAL language is strongly supported. In addition, a JOVIAL compiler for several computers is available. This is a distinct advantage if, in the future, the simulation program is to be moved to the school site as a tool for school personnel. A complete description of the JOVIAL language can be found in SDC document TM-555/002/04, dated 20 October 1965, The JOVIAL (J3) Grammar and Lexicon.

Two approaches of problem description are employed in the development of the simulation vehicle. The basic design and processes of the vehicle are expressed in the JOVIAL language, which is then translated into the appropriate computer instructions. Any change to the basic design of the vehicle requires a new compilation. Specific problems are described through cards containing the necessary parameters for problem description. New problems can be expressed without a new compilation.

D. GENERAL STRUCTURE OF THE SIMULATION VEHICLE

The simulation vehicle is divided into four primary functional processes; student generator, activities, activity processor, and resource allocation processor. The student generator introduces a student population with assigned characteristics for the simulation run. Activities are functional expressions of events that take place in the model. The activity processor controls the cycles of the model and processes those activities which are to operate for the time period being processed. The resource allocation processor places activities in an active or dormant status for the next cycle of the activity processor, based on the resource requirements of the various activities.

Appendix B (cont)

1. Student Generator

Student information is described in Figure 1 in Table STUD'LOC. Each word of this table provides information for an individual student. Further definition of this table is presented in Section D,3. The following discussion is concerned with the initial definitions given to students in Table STUD'LOC in order for the model to begin its processing.

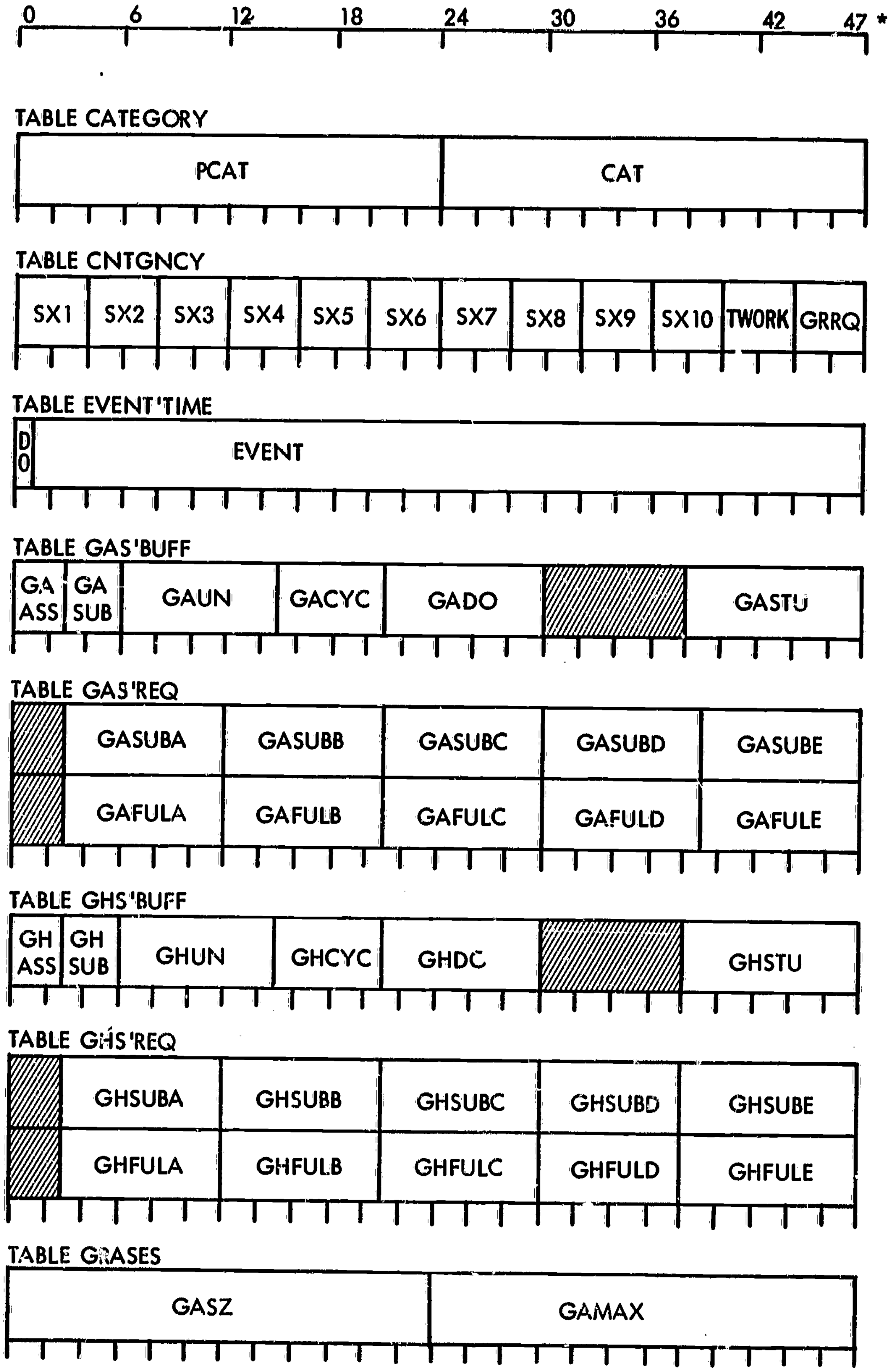
One of the important attributes of the simulation vehicle is a responsiveness to the individual characteristics of students. Decisions of the model with regard to duration and sequence of activities are sometimes based on these different student characteristics. Certain items of information for the student in Table STUD'LOC such as class code (CLS), expected rate of performance (DRATE), and measure of achievement (DTIME) form a basis for determining individual student behavior in the model. The class codes and rates of performance for the students are generated prior to the simulation run.

Class codes and expected rates of achievement are generated for the population of students according to distribution parameters provided in Table CATEGORY. Population characteristics are an important element in determining the total system performance of the simulation model. Thus, one would want to define a population set which is an approximation of the expected population characteristics for the school being simulated. Table CATEGORY in Figure 1 defines the class codes (CAT) to be selected according to the distribution parameters (PCAT) in order to set the class codes (CLS) in each individual student record in Table STUD'LOC. The total population of students for the simulation run is determined by the setting of item NSTUD. Class code selected is used in determining the setting of expected rate of performance (DRATE) in the individual student record.

In addition to the characteristics of the students, further definition is needed for the student with regard to the initial activity of the model. Further reference can be made to the flow diagram of subroutine GENERATE in Figure 2.

2. Activities

An activity is defined as a computer process which functionally represents a task as described by the model and has an associated cost in time and resource.



* THIS SCALE REPRESENTS THE BIT CONFIGURATION, AND APPLIES TO ALL TABLE DEFINITIONS.

Figure 1. Table Format Descriptors (Page 1 of 3)

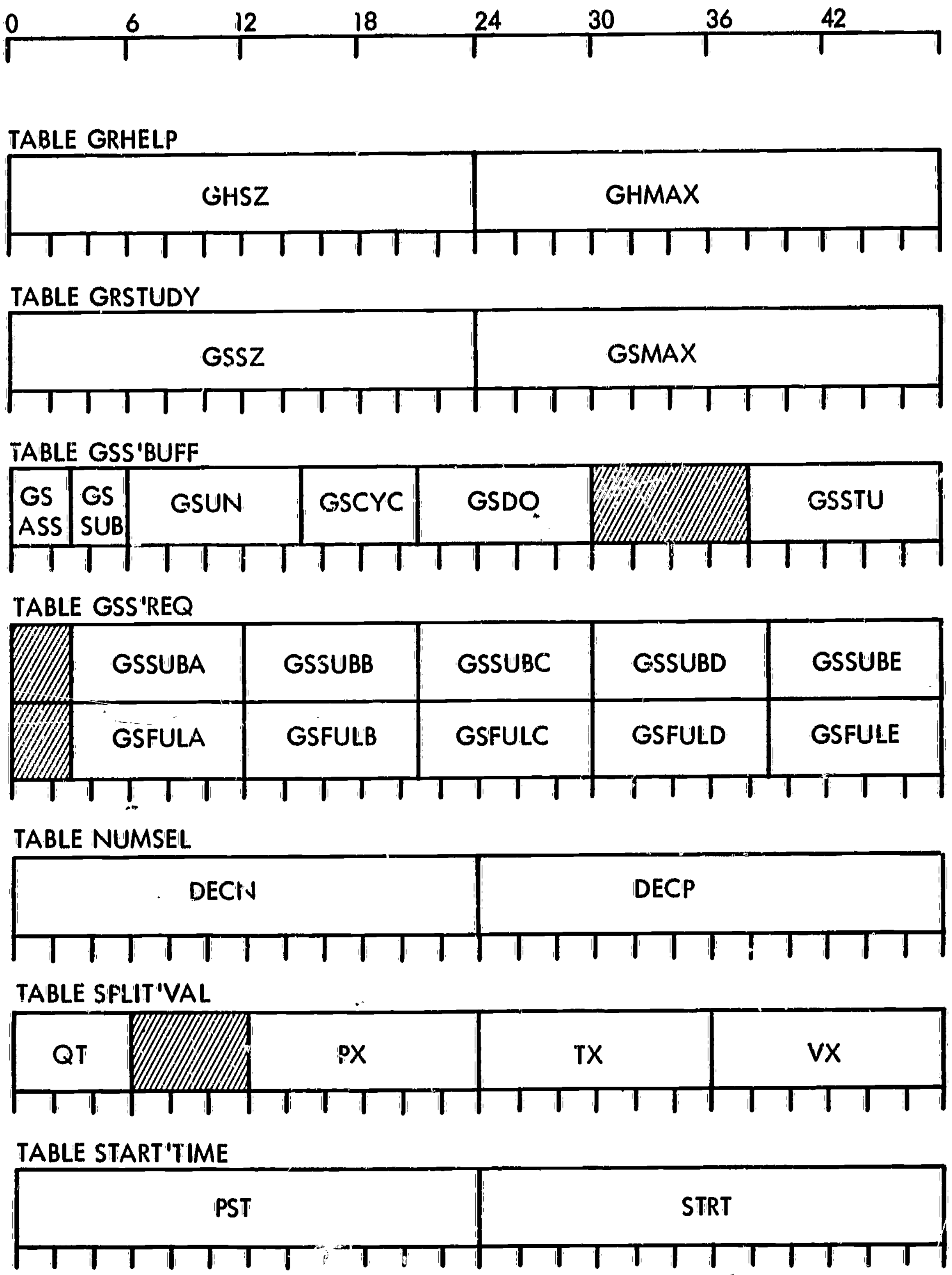


Figure 1. Table Format Descriptors (cont)
(Page 2 of 3)

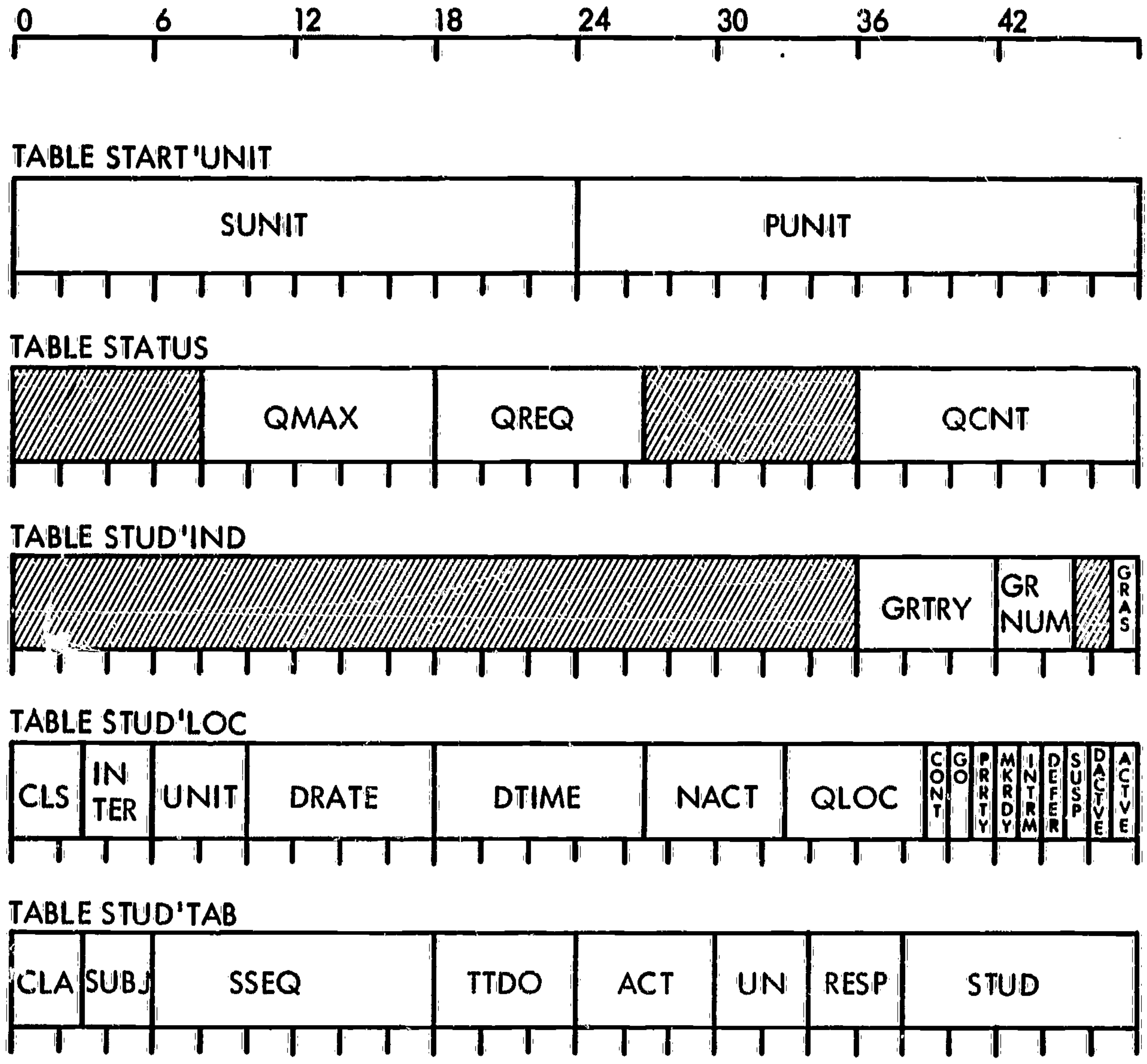


Figure 1. Table Format Descriptors (cont)
(Page 3 of 3)

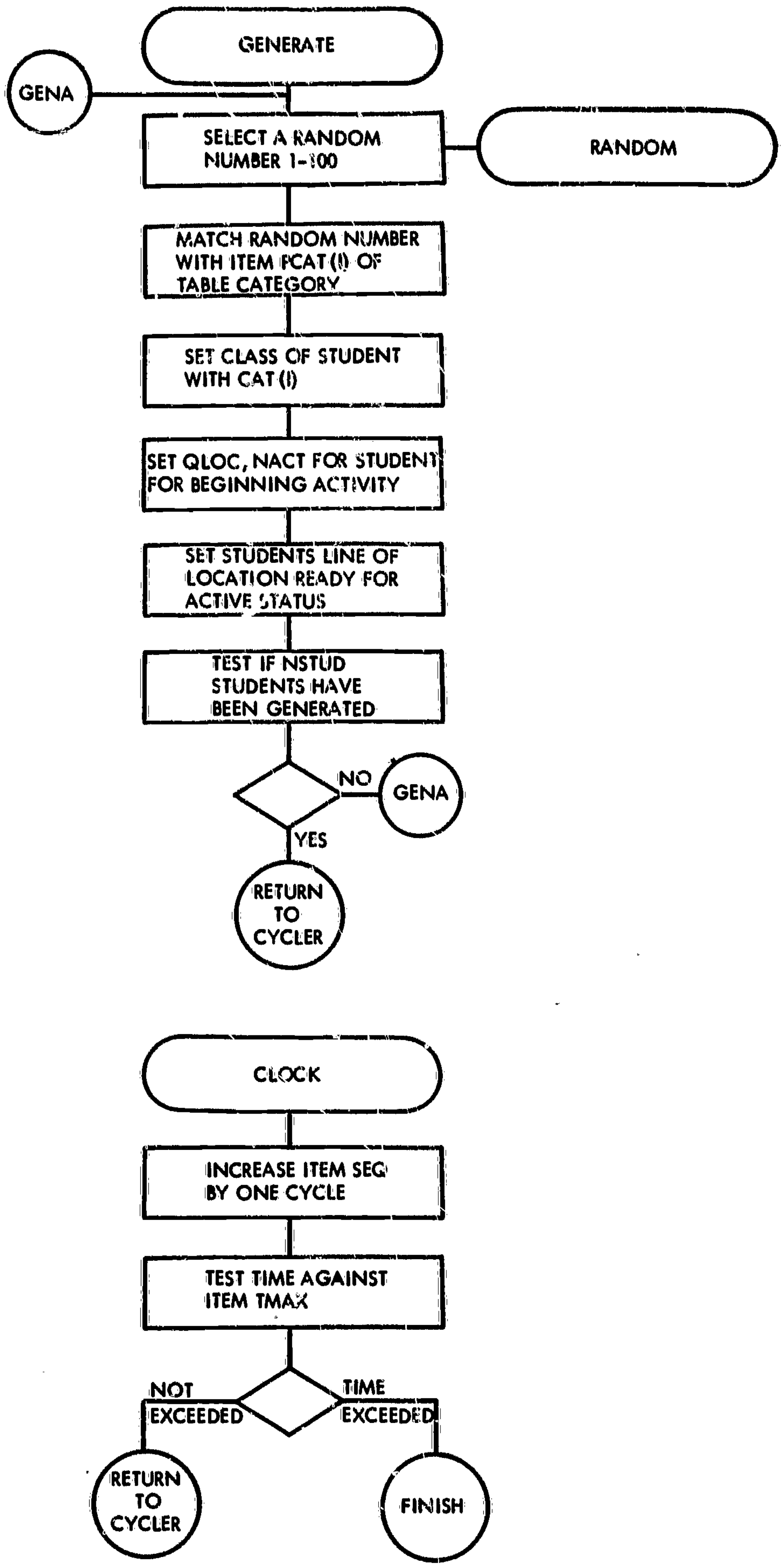


Figure 2. Subroutine GENERATE and CLOCK

Appendix B (cont)

a. Modularity

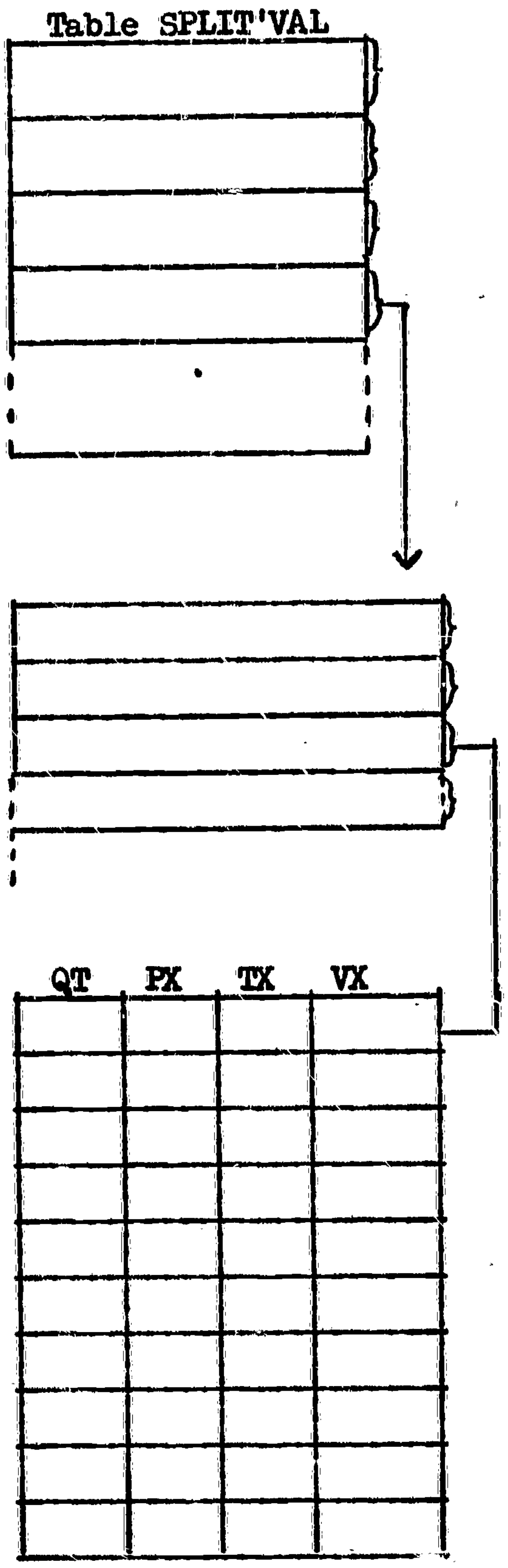
There are 60 activities which can be handled by the simulation vehicle. Each of these activities is modular in the sense that all logical connections between activities are handled external to the activity itself. This organization enables any changes to be made to the logical connections between activities free from internal conflict. In addition, the model may readily be expanded to more than 60 activities, if necessary. The capacity of computer memory is the only limitation.

b. Model Definition of an Activity

Each activity in the model has a unique program label of the form QS(xx) where (xx) represents a number which is associated to a given activity. Activity numbers for the 60 activities in the present vehicle range from 0 to 59.

Associated with each activity is a block of 200 words (shown in Figure 3 in Table SPLIT'VAL) which contains parameters necessary for the decision-making processes of the activity. This 200-word block is further divided into 20 subblocks, each subblock containing 10 words. A subblock is chosen at the activity according to operational rules defined in the activity. The operational rule provides an index for the proper subblock. Each 10-word subblock defines the values of an accumulative distribution table in the range of 0 to 100%. Distribution values are defined for each logical path which may follow as a result of the decision process. There is, therefore, a maximum of 10 possible paths for each of 20 possible decision rules for an activity. The distribution values are expressed in item PX (see Figure 1 for Table SPLIT'VAL). The specific choice is made by comparing a number (range 1 to 100) given by a random number generator (subroutine RANDOM) with item PX. If the random number is less than or equal to the value expressed in item PX, the choice has been selected. If the random number is more than the value expressed in item PX, the comparison is made with the next value of PX until the "less than or equal to" condition has been satisfied. Once the word choice has been made, item TX defined in the word is used to set the time of the activity in cycles, item VX is used to code the path which will be followed upon completion of the time assigned to this activity, and item QT is used to define the activity number to which the student will be next assigned. (Reference Figure 4, below.)

Appendix B (cont)



200 word block for activity zero

200 word block for activity one

200 word block for activity two

200 word block for activity three

10 word subblock for rule index 0

10 word subblock for rule index 1

10 word subblock for rule index 2

Values of items in subblock 3

QT	PX	TX	VX
0	0	0	0
2	80	8	1
4	90	5	2
5	100	3	3
0	0	0	4
0	0	0	5
0	0	0	6
0	0	0	7
0	0	0	8
0	0	0	9

Figure 3. Definition of Table SPLIT'VAL

Appendix B (cont)

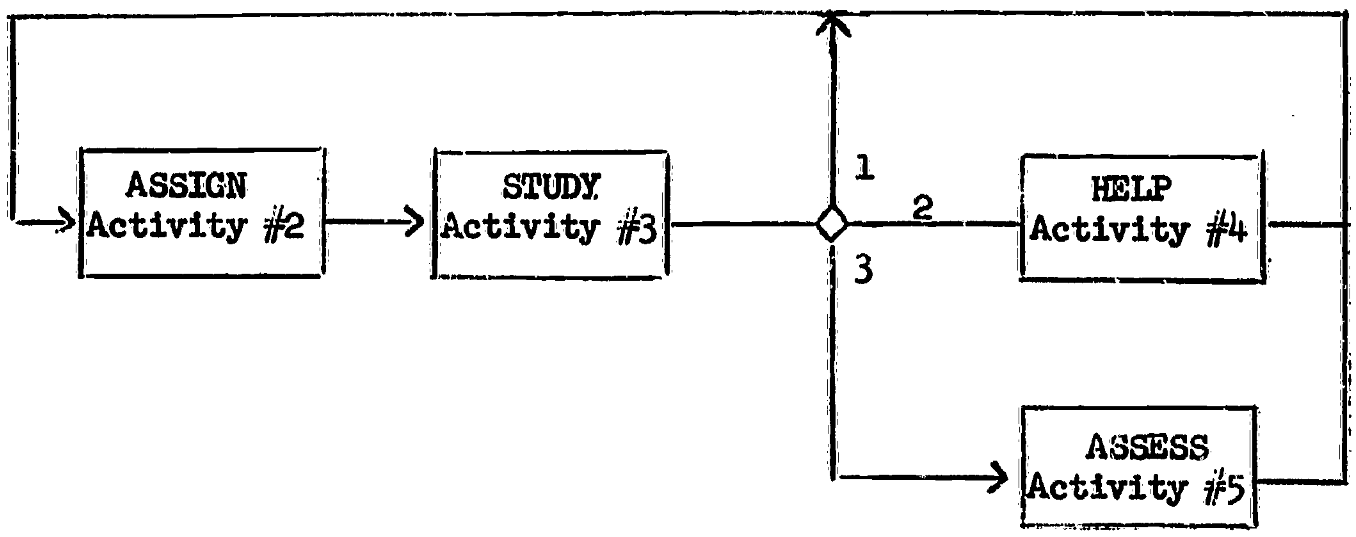


Figure 4. Activity Flow Illustration

Activity three is assigned the function called STUDY. The decision rule for branching and time spent in STUDY will be based on the student's CLASS code. Activity STUDY has three possible subsequent paths expressed as shown.

CLASS two students will perform according to the following distribution rules:

CLASS	Branch 1	Branch 2	Branch 3
2	80%	10%	10%

Parameters for the decision rules for activity three are first indexed by the fourth 200-word block in Table SPLIT'VAL. Activity three will index the third 10-word subblock for students in CLASS two.

The random number generator generates number 87 as its choice. Thus after comparison of the random number with item PX of block four, subblock three, word three (Reference Figure 3), activity STUDY will be assigned a cycle time of five and will then take branch two to activity four defined as HELP.

Appendix B (cont)

Generally, an activity (see Figure 5) performs the following tasks for each student:

- Assigns an activity number.
- Operates special rules which determines the choice of distribution table.
- Selects a random number which will be tested against the selected distribution table.
- Sets the time to be spent in the present activity for the choice selected.
- Sets the path which the student will follow upon completion of this activity for the choice selected.
- Sets the activity to which the student will next be processed in item (NACT) of the student record for the choice of path selected.
- Records all decision-making and identification items for data reduction at a later time.

c. Contingency

There may be cases where a specific decision will be forced because of a previous path or condition for a student. For example, if a student has just been through the assess activity, the logical assumption might be that he would not immediately return to that activity after only one more STUDY activity. Thus contingency item SX1-SX10 may be set when a specific path has been chosen in the simulation. Then in a later sequence of activities, this contingency is tested to determine if the condition exists. If so, the decision path will be forced at the activity instead of performing the random selection of paths.

3. <u>Activity Processor</u>

Control of the events taking place during the current time cycle is accomplished by the Activity Processor, sometimes also referred to as the Cycler. The students and activities which are to be processed are dependent on the active or dormant status of the <u>line of location</u> defined in Table STUD'LOC. Status definitions will be explained in further detail in the Resource Allocation

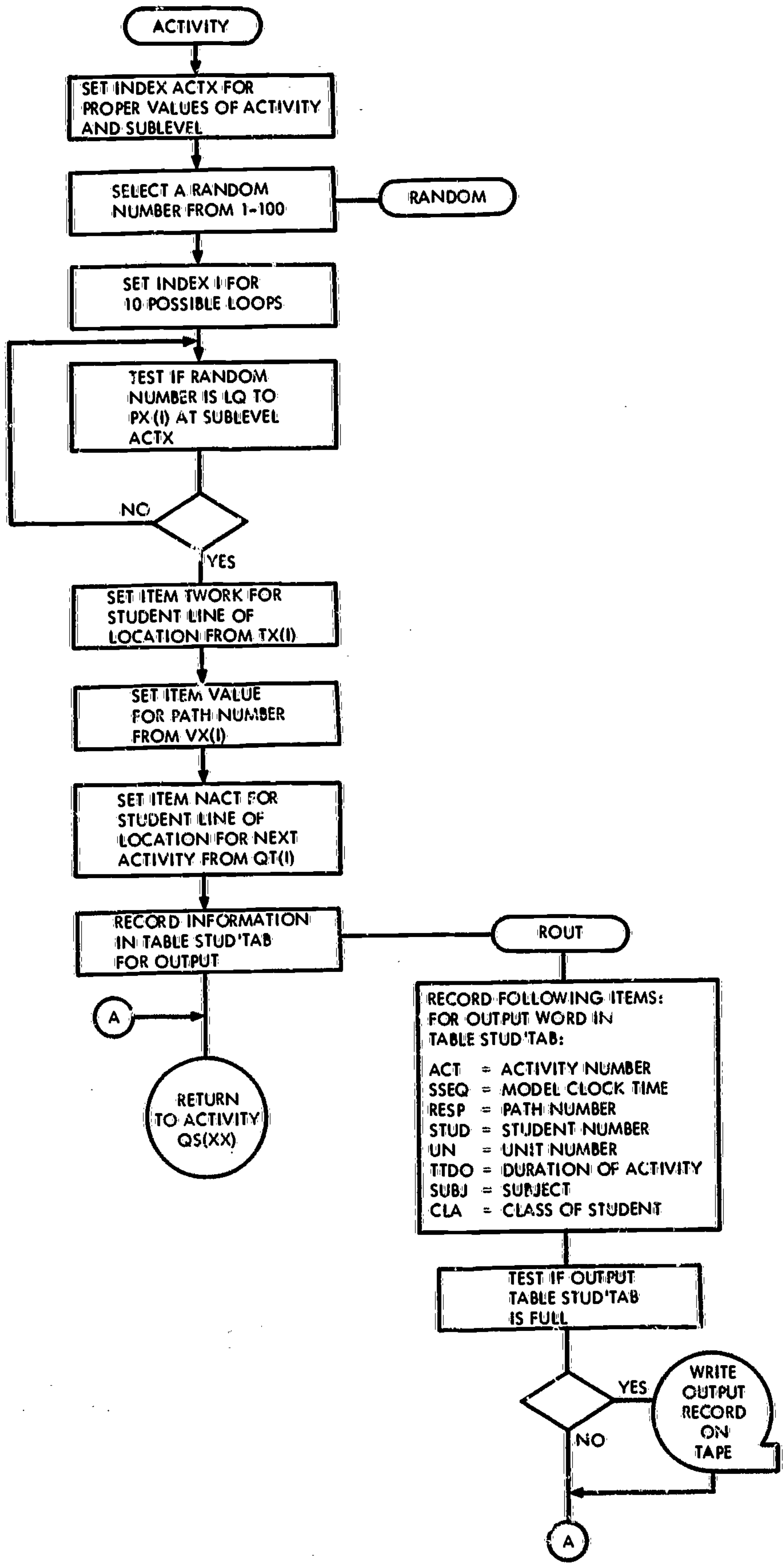


Figure 5. Subroutine ACTIVITY

Appendix B (cont)

Processor discussion presented below. The following paragraphs explain the data structure and functional processes associated with the Activity Processor.

a. Line of Location

Table STUD'LOC defines the items of information to be identified with each student in the simulation with regard to his classification (CLS), unit of study (UNIT), expected rate of achievement (DRATE), actual achievement (DTIME), activity which will follow the present activity when completed (NACT), activity in which he is presently engaged (QLOC), and status definitions. The only status definition of concern to the Activity Processor is ACTVE.

	Meaning
ACTVE = 0	Student is actively engaged in activity QLOC.
ACTVE = 1	Student is in dormant status although logically located in activity QLOC.

Each word definition in Table STUD'LOC is known as the student's <u>line of location</u>. There are 500 lines of location defined by the table. This provides the capability of providing 500 individual tracks in the system. Lines of location may be grouped together to form blocks associated with a student. Thus, each student may be logically or physically placed in <u>n</u> separate queues or activities in the model, where <u>n</u> represents the number of lines of location associated with a student. However, when one assigns multiple lines of location to a student he reduces the maximum number of students who can be processed in the vehicle. This is not a rigid rule, however, for the only limit on the size of Table STUD'LOC is available memory. The table structure for lines of location which one will want to set is normally defined by the type of problem being simulated. We found it convenient to associate five lines of location to each student in problems which would allow students to be simulated in five separate courses of study. In this case, the five word line of location block would be indexed by student number (STUDENT); the specific word within the block would be indexed by a value containing subject number (SUBJECT). This provides, then, a multiple track capability as far as the physical and/or logical status of a student is concerned.

b. Time Control

The duration of time in the model is expressed in cycles. A cycle may be defined as any unit of time such as minutes, fractions of hours, days, weeks, months, years, etc. Normally a cycle definition is set which expresses the

Appendix B (cont)

minimum time expected for the completion of any activity. All associated times to activities must be expressed in cycle units relative to the unit cycle definition. For example, if a cycle is defined as 1/8th of an hour, or 7 1/2 minutes, three cycles represent 22 1/2 minutes. Once the cycle definition is set, it applies as the standard time measure for the simulation run.

We found it convenient to choose a cycle time of 1/8th of an hour for some of our simulation runs because we could not conceive of any activity in the defined model taking place for less than 7 1/2 minutes.

Associated with each line of location in Table STUD'LOC is a parallel line of location in Table EVENT'TIME. The line of location in Table EVENT'TIME expresses, in cycles, the time left in activity (QLOC) before coming to completion. Duration of time left in the activity is represented by the number of binary positions, reading from left to right, before a "1" is encountered in the bit structure of the word.

Table I. Expression of Cycle Times

Duration of Time in Cycles	Associated Binary Number in Table EVENT'TIME
0	10000.....
1	01000.....
2	00100.....
3	00010.....
4	00001.....

The reduction of time against each activity in an active status is accomplished by shifting the bits one position to the left for each cycle processed by the activity processor. The left-most bit is defined as item DO and is tested by the activity processor for controlling those activities and students which will operate during the current time cycle.

A clock time is also kept in the model in terms of cycles (item TIME) and is incremented by one for each complete operation of the activity processor.

Appendix B (cont)

c. Logical Interpreter

Organization of the sequence of activities in the model is accomplished through a switching technique available in the JOVIAL programming language. A switch is expressed as a series of program labels which are referenced by an index. The index used in this case is the number of the activity to be processed.

```
SWITCH SWACTI = (QS0, QS1, QS2, QS3 . . . . . QS59) $

    GOTO SWACTI ($ACTIVE$) $
```

SWITCH SWACTI declares the program labels for each of the 60 activities which can be referenced on ACTIVE values of 0-59. For example, if item ACTIVE is set to a value of three, the GOTO statement will transfer the program to operate the set of instructions at program label QS3. Upon completion of the set of instructions at QS3, the program returns control to the activity processor for examination of the next line of location. Having this means of controlling the transfer in and out of activities on the value of item ACTIVE implies that there is a logical method of setting item ACTIVE when a student is found to be ready by the activity processor.

Items QT of Table SPLIT'VAL define the possible activities which will follow in logical sequence for every activity expressed in the model. Values are in terms of activity number and are set by card input prior to the simulation run. One of the tasks of an activity is to set item NACT of the student line of location with the activity number to which the student will subsequently be processed (Reference Section D,2,b). Item QT is used to provide the value for this setting. Item QLOC in the student line of location defines the activity number in which the student is presently engaged. When the Resource Allocation Processor (further discussed in Section D, 4) determines that activity QLOC has come to completion, it resets item QLOC with item NACT which effectively shifts the student's location from the present activity to the next activity. Thus, when the activity processor finds that a line of location is ready for a new activity, the new activity is defined in item QLOC. Item ACTIVE is set to the value of item QLOC, and the above switch declaration can be effected. The advantage of using this method of logical expression means that logical ties to activities can easily be changed by altering the values of items QT on successive simulation runs. It is conceivable that a system modification could be accomplished <u>during</u> the simulation run by an interrupt process from the activity processor which alters the values of QT, although we have not attempted this to date in our simulation studies.

Appendix B (cont)

d. Functional Description

A summary of the functions controlled by the Activity Processor follows: Reference to the flow diagram of the Activity Processor shown in Figure 6 may be helpful. The functions are explained as follows:

Function (1) Process each line of location in Table STUD'LOC and determine status of item ACTVE.

ACTVE = 0 line of location is active. Proceed to Function (2).

ACTVE = 1 line of location is dormant. Proceed to Function (6).

Function (2) For each line of location where ACTVE = 0, test item DO of the corresponding line of location in Table EVENT'TIME.

DO = 0 line of location is an ongoing activity. Proceed to Function (5).

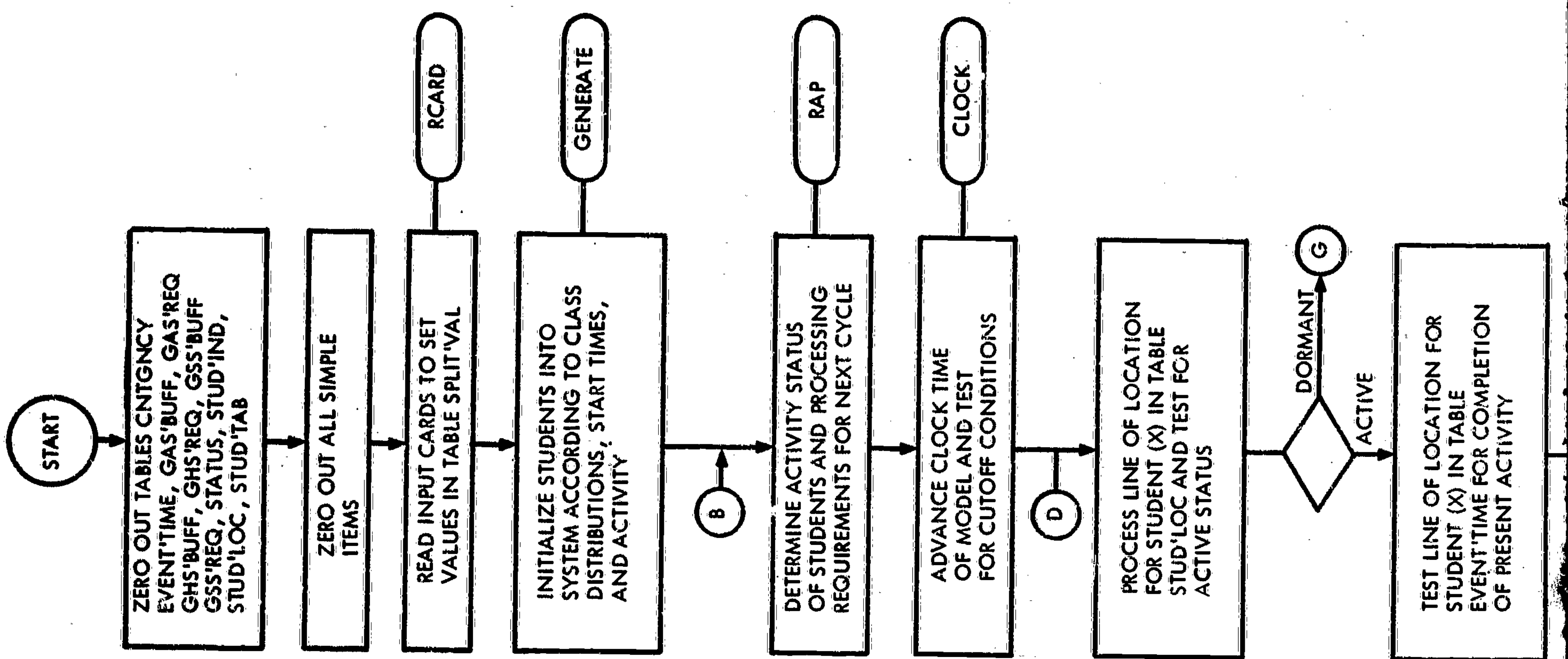
DO = 1 line of location is a completed activity. Proceed to Function (3).

Function (3) For each line of location where ACTVE = 0, DO = 1, transfer control of the program through SWITCH SWACTI to the activity defined in item QLOC of line of location. The activity is processed as outlined in Section D,2. Proceed to Function (4).

Function (4) Test the duration of time assigned to the activity processed in Function (3). If the time assigned is zero, the activity was logical in interpretation and processing returns to Function (3). If the time assigned to the activity processed in Function (3) is not zero, set bit n of the line of location in Table EVENT'TIME where n = the number of cycles assigned to the activity. Proceed to Function (5).

Function (5) Shift the line of location in Table EVENT'TIME left one bit for advance of time. Proceed to Function (6).

Function (6) Increment index for line of location and test if all lines of location have been examined. If lines of location remain, return to Function (1). Otherwise, proceed to Function (7).


START
ZERO OUT TABLES CNTGNCY EVENT'TIME, GAS'BUFF, GAS'REQ GHS'BUFF, GHS'REQ, GSS'BUFF GSS'REQ, STATUS, STUD'IND, STUD'LOC, STUD'TAB
ZERO OUT ALL SIMPLE ITEMS
RCARD
READ INPUT CARDS TO SET VALUES IN TABLE SPLIT'VAL
GENERATE
INITIALIZE STUDENTS INTO SYSTEM ACCORDING TO CLASS DISTRIBUTIONS, START TIMES, AND ACTIVITY
B
RAP
DETERMINE ACTIVITY STATUS OF STUDENTS AND PROCESSING REQUIREMENTS FOR NEXT CYCLE
CLOCK
ADVANCE CLOCK TIME OF MODEL AND TEST FOR CUTOFF CONDITIONS
D
PROCESS LINE OF LOCATION FOR STUDENT (X) IN TABLE STUD'LOC AND TEST FOR ACTIVE STATUS
DORMANT
G
ACTIVE
TEST LINE OF LOCATION FOR STUDENT (X) IN TABLE EVENT'TIME FOR COMPLETION OF PRESENT ACTIVITY

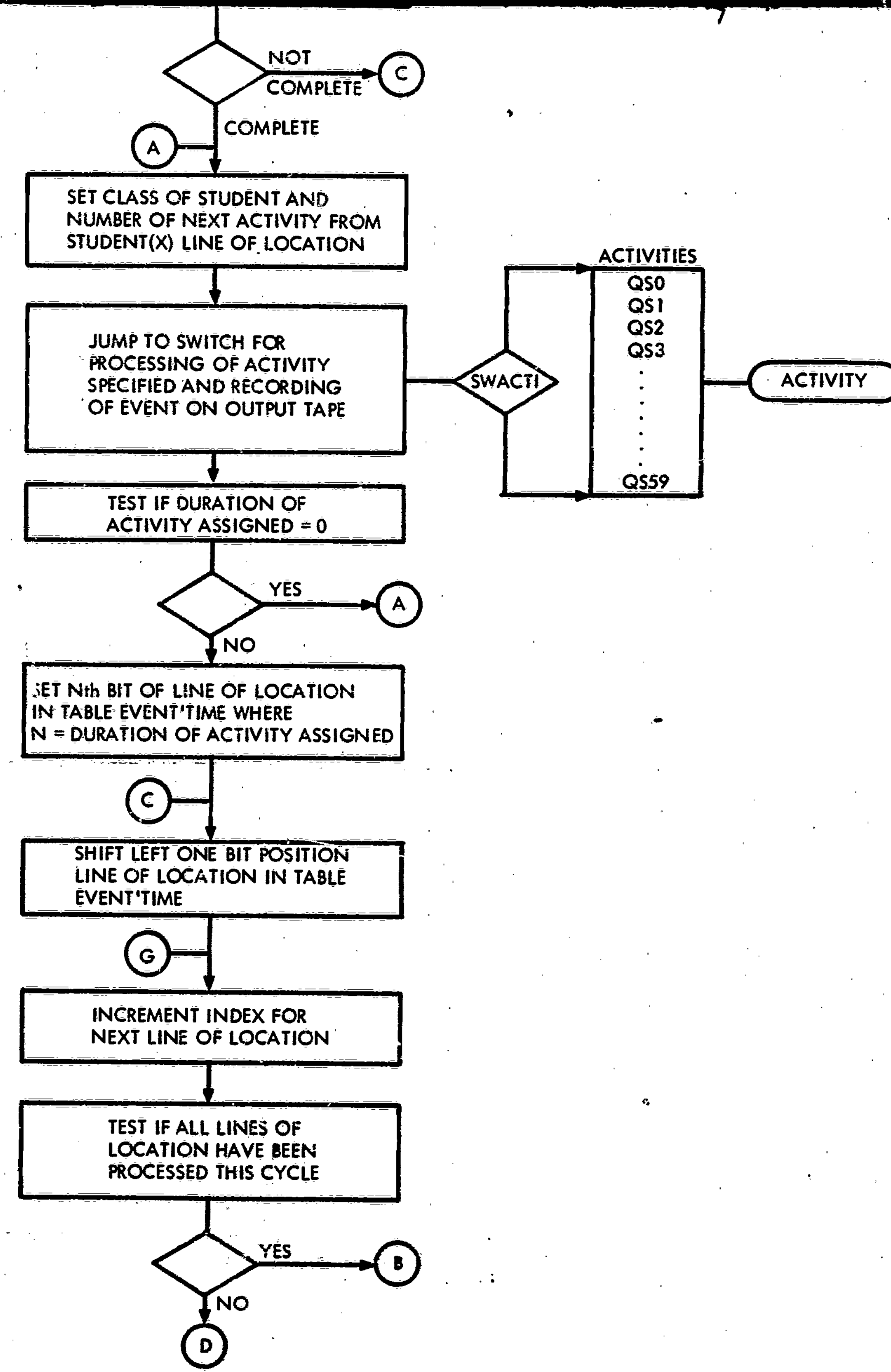


Figure 6. Activity Processor

Appendix B (cont)

Function (7) Cycle clock time is interrupted and processing control is transferred to the Resource Allocation Processor for determining lines of location status for the next time cycle. Control is returned to the Activity Processor. Proceed to Function (8).

Function (8) Clock time in the model is incremented by one cycle. Item TMAX is tested to determine if amount of time for problem simulation is reached. If not, return to Function (1) for continuation. If yes, problem simulation is completed.

4. Resource Allocation Processor

The Resource Allocation Processor provides status definitions to each line of location in Table STUD'LOC for the next cycle of the Activity Processor. The status definitions are set after analysis of the required resources and logical flow of the model relative to time. The Resource Allocation Processor is entered between cycles of the Activity Processor. The processing capability it provides can be considered similar to the data processing requirements of a school which operates between class sessions. The frequency of the data processing requirement is dependent on the definition of time given to a cycle. Thus, if cycles represent days, the data processing functions operate after the school day and schedule students into appropriate locations for the coming school day. However, if the cycle definition is in hours or fractions of hours, the data processing requirements are provided on that frequency. A diagrammatic expression of the Resource Allocation Processor is described in Figure 7.

The capability of assigning resources in the vehicle is not currently implemented, although the logical capability is provided in the Resource Allocation Processor. Activities taking place in the model require only the logical or physical presence of a student for an activity. A logical presence is required where activities process functions for the student. A physical presence is required where activities process functions with or by the student. Thus an activity such as a review of a student record by a guidance counselor demands only the logical presence of the student in terms of his cumulative record.

a. Status Definitions

Activities processed by the Activity Processor for the previous cycle are in terms of status item ACTVE which represents the active and dormant lists. Activity numbers for each line of location are expressed in item QLOC. The

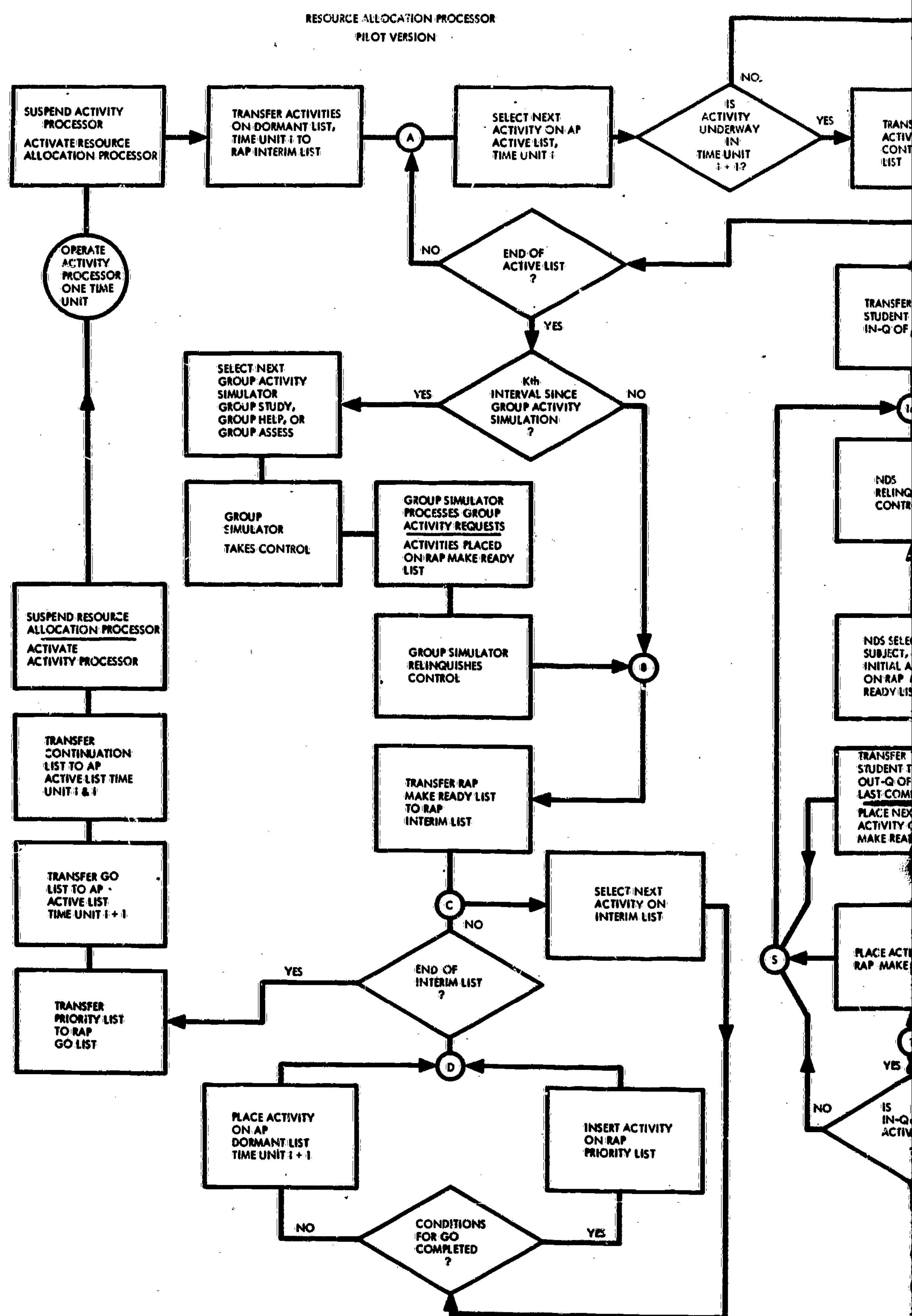
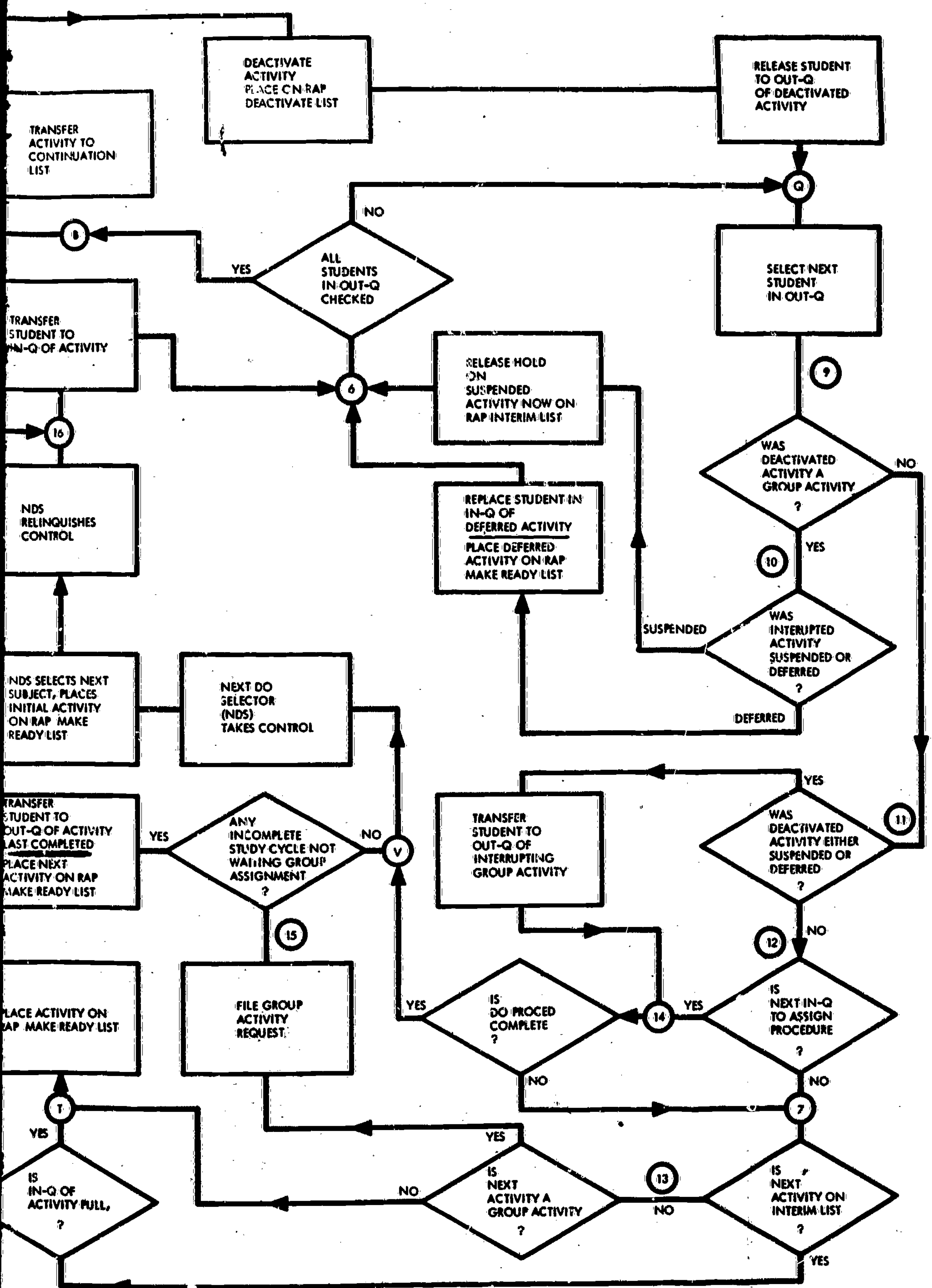


Figure 7. Resource Allocation Processor


DEACTIVATE ACTIVITY PLACE ON RAP DEACTIVATE LIST
RELEASE STUDENT TO OUT-Q OF DEACTIVATED ACTIVITY
TRANSFER ACTIVITY TO CONTINUATION LIST
NO
YES
ALL STUDENTS IN OUT-Q CHECKED
SELECT NEXT STUDENT IN OUT-Q
TRANSFER STUDENT TO IN-Q OF ACTIVITY
RELEASE HOLD ON SUSPENDED ACTIVITY NOW ON RAP INTERIM LIST
WAS DEACTIVATED ACTIVITY A GROUP ACTIVITY ?
NO
REPLACE STUDENT IN IN-Q OF DEFERRED ACTIVITY
PLACE DEFERRED ACTIVITY ON RAP MAKE READY LIST
NDS RELINQUISHES CONTROL
YES
SUSPENDED
WAS INTERUPTED ACTIVITY SUSPENDED OR DEFERRED ?
DEFERRED
NDS SELECTS NEXT SUBJECT, PLACES INITIAL ACTIVITY ON RAP MAKE READY LIST
NEXT DO SELECTOR (NDS) TAKES CONTROL
YES
TRANSFER STUDENT TO OUT-Q OF ACTIVITY LAST COMPLETED
PLACE NEXT ACTIVITY ON RAP MAKE READY LIST
YES
ANY INCOMPLETE STUDY CYCLE NOT WAITING GROUP ASSIGNMENT ?
NO
TRANSFER STUDENT TO OUT-Q OF INTERRUPTING GROUP ACTIVITY
WAS DEACTIVATED ACTIVITY EITHER SUSPENDED OR DEFERRED ?
NO
PLACE ACTIVITY ON RAP MAKE READY LIST
FILE GROUP ACTIVITY REQUEST
YES
IS DO PROCED COMPLETE ?
YES
IS NEXT IN-Q TO ASSIGN PROCEDURE ?
NO
NO
YES
YES
IS IN-Q OF ACTIVITY FULL ?
NO
IS NEXT ACTIVITY A GROUP ACTIVITY ?
NO
IS NEXT ACTIVITY ON INTERIM LIST ?
YES

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Appendix B (cont)

active list consists of those activities under way during the previous cycle where item ACTVE = 0. The dormant list consists of those activities which are inactive during the previous cycle where item ACTVE = 1.

At the end of the previous cycle, the Resource Allocation Processor gains control and the following status definitions are considered:

Interim list--contains all activities on the dormant list during the previous cycle which may be placed under way for the next cycle provided physical and/or logical presence of students and resources are available. The item INTRM is equal to 1.

Continuation list--contains all activities which are on active list for the previous cycle and will continue in active status for the next cycle. The item CONT is equal to 1.

Deactivate list--contains all activities which were active during the previous cycle but which terminated at end of the previous cycle. Assignment of students into a next activity (item NACT) is accomplished by setting items QLOC = NACT, provided the requirements of the next activity are met. The item DACTVE is equal to 1.

Make Ready list--contains all activities which are not already on the interim list but which may be later placed on the interim list provided all requirements of resource are met. The make ready list by definition includes all those activities which must be considered for the interim list because they are the next activities defined as a consequence of processing the deactivate list. Item MKRDY = 1.

Priority list--contains all activities on the make ready list which meet resource requirements. At this point there is the logical capability of placing priorities on certain activities over and above those of resource. In the present version, students are treated in a first-in, first-out priority so this list definition does not have any real significance although the means of priority expression is defined for future implementation. Item PRRTY = 1.

Go list--made up of all activities which meet resource requirements for the next cycle. The go list and the continuation list are combined to form the active list for the next cycle. All other activities are placed on the dormant list for the next cycle.

Appendix B (cont)

There are two special status definitions which apply to the interruption of activities. An activity may be interrupted by other activities which operate on a scheduled time base. The time of operation of the scheduled activities is controlled within the Resource Allocation Processor. The particular case implemented in the vehicle is the formation of groups at set cycle intervals. Students continue to engage their normal sequence of activities until such time when they are considered for group formation. Those students who then enter a group activity are placed in deferred or suspended status according to the following definition:

Deferred list--those activities which would have been made ready for the next cycle but are interrupted for group activity. After group activity is completed, the deferred activity is entered for normal processing. The item DEFER is equal to 1.

Suspended list--those activities which are ongoing during the previous cycle and are suspended for a group activity. After the group activity is completed, the suspended activity is entered for processing for the time duration left in the activity at time of interruption.

b. Next Do Selector

Section D,3,a, above defines the students' line of location for Tables STUD'LOC and EVENT'TIME. It was stated that blocks of "lines of location" may be assigned to students providing a multiple track capability in the vehicle. For example, a block of five lines of location may represent five separate courses in which the student is progressing, the progress in each line of location being independent. The model then must be capable of deciding which line of location is to be considered for the next cycle. Normally, there is a set sequence of activities for a line of location which must come to completion before assignment to another line of location takes place. The sequence of activities is defined by the organizational structure of the model being simulated. Any interruption for a line of location, such as a group request or completion of a set sequence of activities forces the operation of a subroutine called the Next Do Selector (NDS). This subroutine provides a method for making each student's program of study a unique program. The NDS chooses the next line of location according to a set of assignment rules or by random choice. Rules may express conditions such as not allowing the same line of location to be selected in sequence, assigning distribution parameters for the frequency of choice of certain lines of location, or incrementing item DTIME on a certain selection to represent achievement because of homework accomplished. The parameter distributions are assigned in Table NUMSEL. Item DECP expresses the distribution and item DECN provides a scheduling integer for assigning the line of location in the block.

Appendix B (cont)

A functional description of the NDS subroutine (Figure 8) is presented below:

Function 1	Randomly select a next scheduling integer from Table NUMSEL according to distribution parameters. Continue to Function 2.
Function 2	Test if the scheduling integer selected is permissible. If yes, proceed to Function 3. If no, return to Function 1.
Function 3	Test if the scheduling integer chosen is zero. If yes, increment item DTIME of present line of location and return to Function 1. If no, continue to Function 4.
Function 4	Place activity in chosen line of location on make ready list. Continue to Function 5.
Function 5	Return control to Resource Allocation Processor.

c. The Group Simulators

There are three processes within the Resource Allocation Processor that provide the capability of forming groups of students. These processes are entered at set intervals of time expressed as a function of item KCYCLE. The three processes logically perform the same functions but have their own table and item definitions. We have given definition to the three processes in terms of the functions in our school simulation to which they apply. In our conception of the school model there is the possibility of forming groups in assess, help, and study procedures. Therefore our three group simulators are defined as group assess, group help, and group study. All table and item definitions related to each of the simulators starts with the letters GA, GH, or GS for Group Assess, Group Help, and Group Study, respectively. A group activity is identified in the Resource Allocation Processor by the activity number contained in items GAACT, GHACT, and GSACT. The Resource Allocation Processor, when processing a line of location to determine its status for the next cycle, tests the three items just mentioned to determine if the next activity for the line of location is a group activity. If a group activity is identified, the student files a group request in a buffer assigned to each of the three group situations. The following group request applies to the group assess simulator but may be considered the same type of information necessary for group help and group study requests as well.

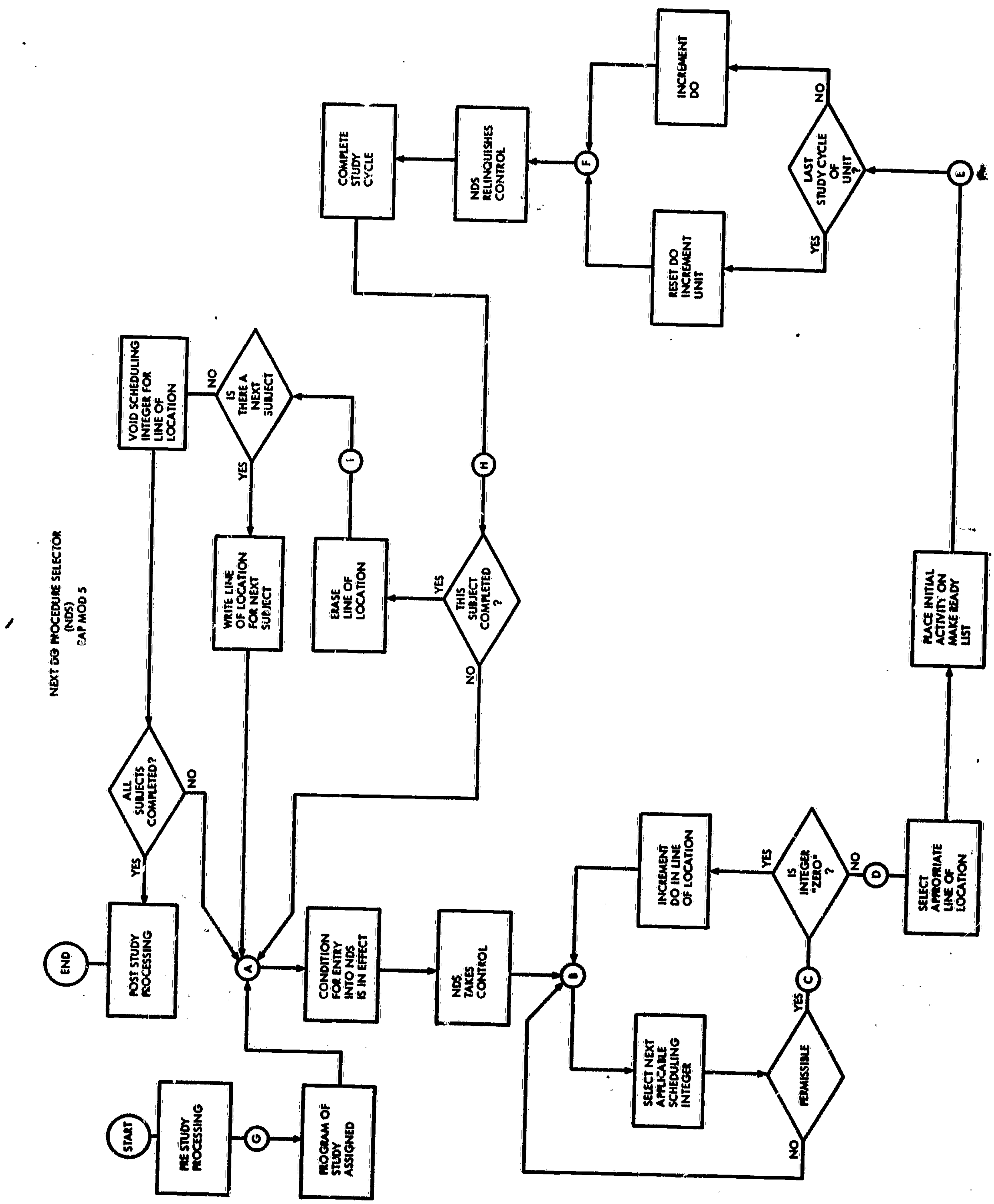

Figure 8. NEXT DO Selector

Appendix B (cont)

Contents of Table GAS'BUFF for group assess request:

Item	Definition
GASTU	Student number
GASUB	Subject number or subline of location
GAUN	Unit number
GACYC	Number of cycles the request has been on file
GADO	Student's achievement at time of request--item DTIME
GAASS	A bit for determining those requests which will qualify. Not set at request time but used within the group assess simulator.

When a request for a group activity has been filed for a specific subject or line of location, the student cannot progress further in the subject until the group request is scheduled and he performs the group activity. Therefore, the Resource Allocation Processor assigns the student to another subject or line of location for the next cycle by the Next Do Selector Procedure outlined in Paragraph b, above. After the Resource Allocation Processor determines the status of all activities and lines of location for the next cycle, a test is performed to determine if it is time for one of the group simulators to operate. Items GATIME, GHTIME, GSTIME contain cycle times for each of the three group simulators. The three group simulators operate on times expressed as a function of three times the number of KCYCLE cycles since the last time of operation. If the condition for entry into a group simulation is met, status definitions as previously set by the Resource Allocation Processor will be altered for group activity priority. Groups of students are formed according to criteria rules established in the simulators. Some of the criteria rules that were established are listed below, but others may be established by the model user.

Criteria 1	Requests are processed starting with the first request in the buffer. The order of requests on file establishes the priority with regard to time.
Criteria 2	Groups are formed for students who are in the same subject.
Criteria 3	Groups are formed for students in the same subject and unit.

Appendix B (cont)

Criteria 4 Groups are formed on the basis of achievement in subject and/or unit by testing items GADO, GHDO or GSDO of the group request.

Criteria 5 Groups are formed on the basis of a group size definition for each subject. Group size definitions are contained in Table GRASES, GRHELP, GRSTUDY for the three group simulators.

Criteria 6 Students who do not qualify for a group after having a group request on file for a maximum number of cycles will be automatically placed in a group so they can continue in the subject. Maximum times for a group request to be on file are contained in items GAMAX, GHMAX, GSMAX in Tables GRASES, GRHELP, GRSTUDY, respectively.

The searching of requests continues until a complete search of all requests on file has been accomplished. Item GAASS, GHASS, or GSASS is set to one for all group requests which meet the criteria of group formations. (Remember that the present model has not implemented a definition of resources for each of the activities. However, at this point of processing in the group simulator, the capacity requirements of the system could be assessed to determine if there is an excess of groups formed in terms of the number of teachers available to handle such groups. If groups are formed that are in excess of capacity the numbers of the groups are returned to the group request buffer for the next scheduled operation. Normally, however, the group size will be set in terms of the system capacity.)

All group requests which meet the established criteria are removed from the buffer and placed on the make ready list for final processing by the Resource Allocation Processor for the next cycle. Group status DEFER or SUSPEND are set according to their definition given in Paragraph a above. At the completion of the group activity, the student will be returned to his interrupted sequence of activities. Since the group request was filled, the student may now continue in the subject for which he had the group request. Control of interrupted activities is maintained by the Resource Allocation Processor.

Group requests which remain on file because of failure to meet the established criteria are placed at the top of the request buffer in order to establish priority for the next scheduled operation of the simulator. In addition, items GACYC, GHCYC or GSCYC are incremented by a function of three times the definition of KCYCLE for determination of Criteria 6. A flow diagram of the Group Study simulator is shown in Figure 9.

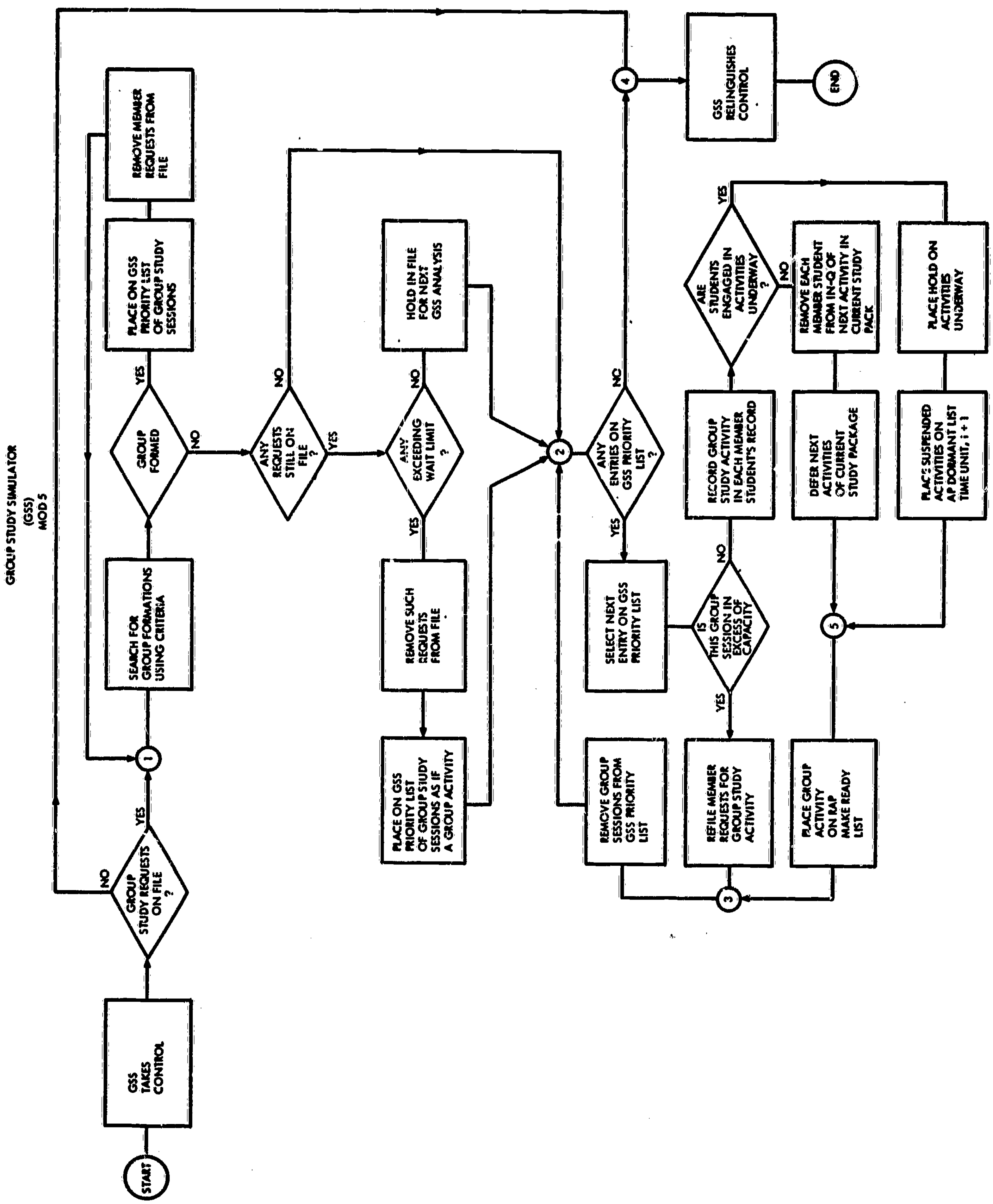

Figure 9. Group Study Simulator

Appendix B (cont)

E. USER INPUT CAPABILITY

One of the necessary requirements for simulation studies is to provide a gaming capability. The efficiency of the organizational structure and activities within that structure is dependent on rules of operation set prior to the simulation run. Communication between the user and the simulation vehicle is provided to set these rules by three different sets of input cards. This area of communication was one of the later developments in the simulation vehicle and does not provide all of the capabilities we would like to implement for input control. To date, input cards provide all of the information necessary to define the parameters of Table SPLIT'VAL. These cards are used by subroutine RCARD (Figure 10). The following column definitions apply to all three types of cards.

Column	Card Type
1	P = Card type code for setting item PX T = " " " " " " TX A = " " " " " " QT
3-4	**Activity Number** Range 0-59. This number is used to set a specific 200-word block of Table SPLIT'VAL assigned to an activity.
6-7	**Decision Rule Number** Range 0-19. This number is used to set a specific 10-word block of Table SPLIT'VAL within the 200-word block specified by activity number.
17-56	Provides parameters necessary for the setting of the four items mentioned. PX values contain percentages for setting the distribution rule for a given activity. TX values contain time in cycles to be applied to the activity defined in columns 3-4. QT values contain activity numbers which will follow next in sequence for each decision path chosen.

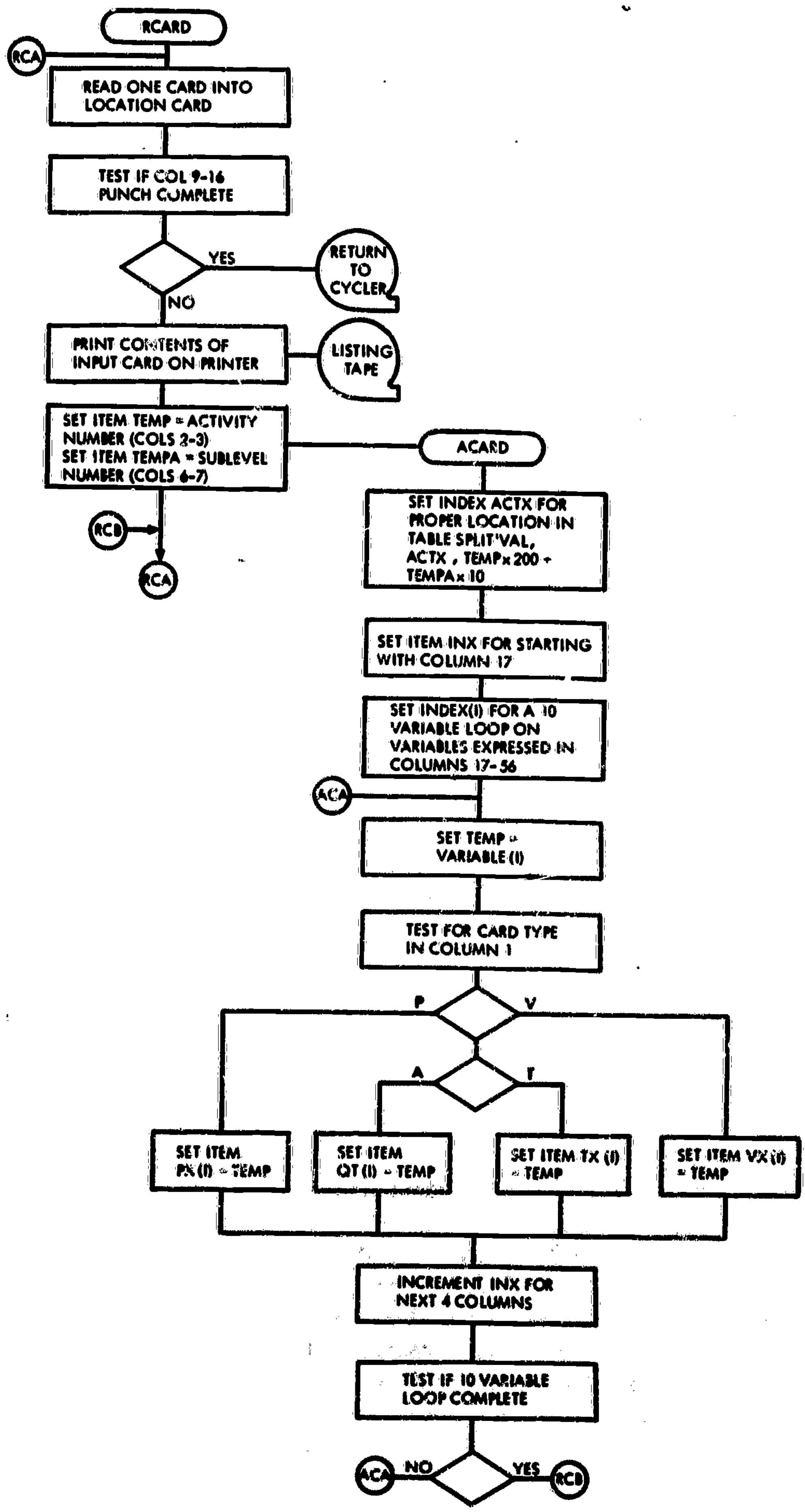

Figure 10. Subroutine RCARD

Appendix B (cont)

1. P Cards

P cards contain the distribution parameters which will be applied at the activity for random selection of the path decision for the activity number in columns 3-4. For each logical path 0-9, the percentage is punched in the corresponding columns for the value assigned to the path. The sum of all percentages defined should always total 100%. In the illustration for the P card in Figure 11, activity STUDY will be assigned to activity 15 in the model. There are six possible decision choices to be decided by random selection. Choice zero will be selected at a frequency of 20%, choice one at a frequency of 10%, choice two at 40%, choice three at 15%, choice four at 5%, and choice five at 10%. Note that these percentages total 100%. Table SPLIT'VAL will be set in item PX for the 10-word block starting at location Z where Z = (activity number) x 200 + (rule number) x 10. Thus for this illustration, PX_{0-9} will be set in table locations 3020-3029 respectively.

2. T Cards

One of the variables assigned to activities is time. T cards contain the time in cycles to be applied to the activity defined in columns 3-4. Thus in the illustration for the T card in Figure 11, the cycle times expressed will be assigned to the activity in the same distribution as expressed on the P card. An additional comment is necessary here because a time of four cycles is shown for choices zero and two. This means in effect that a time of four cycles will be assigned to the activity at a frequency of $P_0 + P_2$ or 20% + 40% = 60%. However, there is a difference expressed on the A card as to the activity which will follow in sequence for P_0 or P_2. Because of this difference, the time of four cycles is expressed for each case.

3. A Cards

A cards contain the activity numbers which follow in sequence for each logical path chosen. The A card in Figure 11 expresses four possible activities which can follow activity number 15 as defined by the systems design configuration. Again it is noted that multiple decision paths may lead to the same activity. Both paths zero and one lead to activity number 16; paths two and three lead to activity number 20. The cards in Figure 11 express all logical path possibilities for activity number 15 when operating under control of operational rule number two.

Appendix B (cont)

Definition	Card Type	Act #	Rule #	Activity Name (Optional)	Parameter values for choices 0 - 9: 0	1	2	3	4	5	6	7	8	9
P Card	P	15	2	Study	20	10	40	15	5	10				
T Card	T	15	2		1.	8	4	6	3	3				
A Card	A	15	2		16	16	20	20	17	18				

Figure 11. Card-Type Definitions and Examples for Problem Input

Appendix B (cont)

F. OUTPUT DISPLAY

The output data generated by the simulation vehicle is a time-based record on tape of every activity which has taken place during the simulation run. Output displays are presented as a result of reducing the recorded variables over time into meaningful summaries for analysis of the data. All recording takes place at the activity level under the control of the Activity Processor. The variables shown in Table II are recorded for output in Table STUD'TAB of the simulation vehicle and are input to a similar table in our list programs.

Table II. Definition of Table STUD'TAB

Item	Definition
CLA	Class code of student
SSEQ	Model cycle time of recording
TTDO	Time in cycles assigned to present activity
RESP	Decision path chosen for this activity which will follow activity completion
STUD	Student number
ACT	Activity number
SUBJ	Subject number
UN	Unit number

Many different types of displays can be constructed from this list of variables. The output displays are generated by a separate computer program named SIMLIST. The organization of SIMLIST is shown in Figure 12. Often the results of a summary listing suggest additional types of summaries for subsequent analysis. As long as no decision rules or organizational change is implied for the new analysis, one only needs to add the new summary capability to the output program. This type of loop analysis continues to improve the data reduction techniques and suggests new ideas for future simulation runs. Another program called STRACE tracks the individual student history through the simulation run. A verbal description of the events taking place is listed along with all of the information defined for Table STUD'TAB above for each student being traced.

Appendix B (cont)

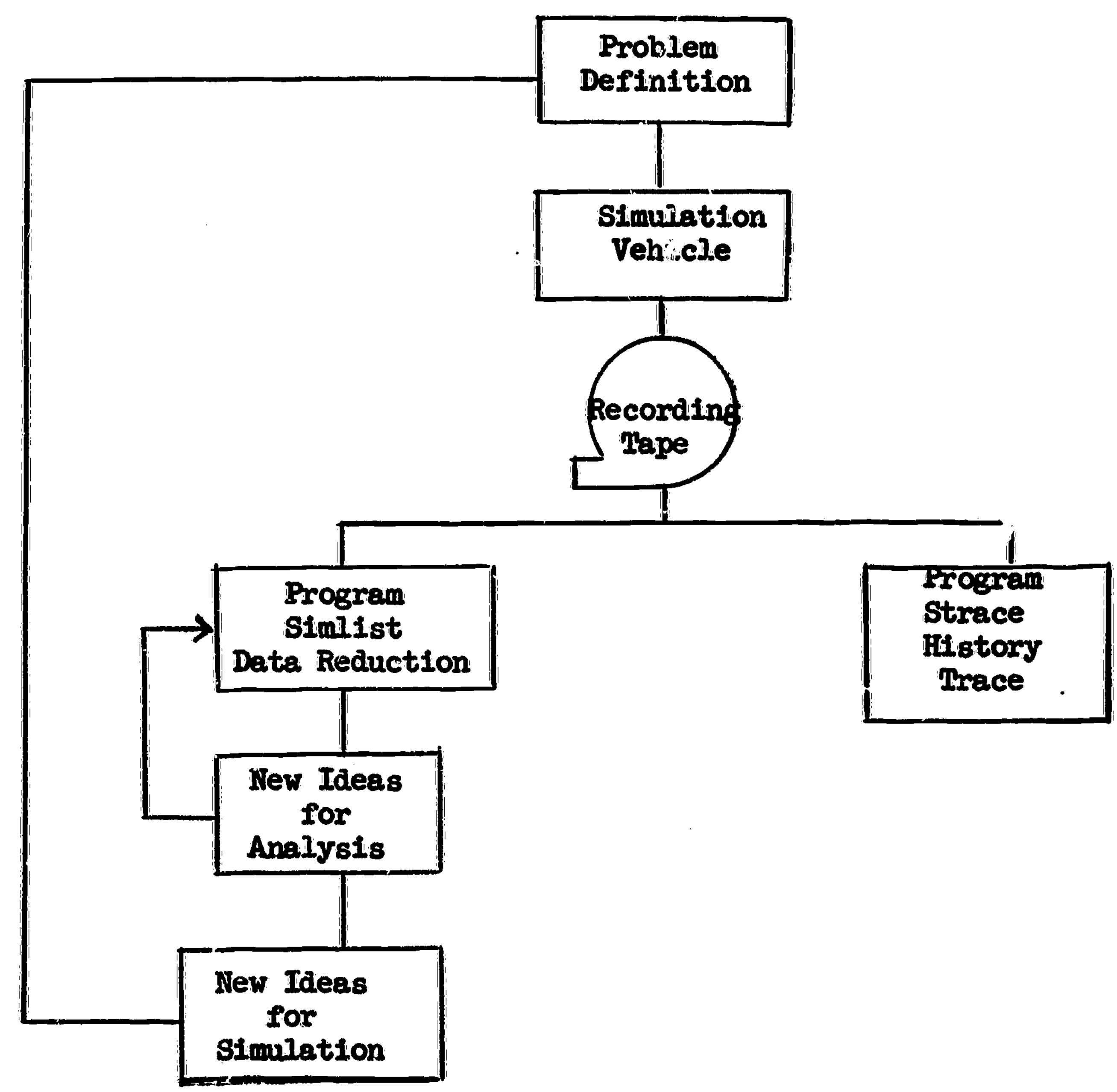

Figure 12. Organization of Simulation System

Appendix B (cont)

1. Program SIMLIST

An attempt has been made to make the output listings readable in terms of the problem being simulated. Since the occurrence of events is in terms of activity number on the output data generated by the simulation, a method of associating a label definition to the activity is needed. Card columns 9-16 of the input deck to the simulation run are reserved for assigning a label to the activity number expressed in columns 3-4. A subset of that deck containing label definitions for each activity in the model can serve as an input deck to program SIMLIST. This input deck is optional to program SIMLIST, for if a deck is not provided the program will assign labels such as ACTIVITY 1, ACTIVITY 2, ... etc., and the user must then make the translation.

There are several types of listings provided by program SIMLIST. Generally, they fall into three different formats, but the meaning of the data to the model user is subject to his own interpretation. Since the tape is ordered by the time of events, all summaries can be generated either for equal segments of time or for the entire problem run. The three types of formats are discussed below:

a. Output Display Type A

A summary for each activity in the model indicating the total number of passes through the activity for a specified time segment is generated in the format outlined in Table III. The totals are shown in the subcategories of class code, subject or line of location, and path decision. In addition the time of the summary is given. In the illustration, it is indicated that the class of fast students who passed through this activity for subject one had a distribution of 135, 10, and 23 students to branches one, two, and three respectively. This type of listing helps to validate the performance of the activity to the model user relative to the distribution parameters and special rules defined for the simulation run. It is obvious that this activity has three decision paths that were used in the simulation. The totals may represent several passes by the same student for the time segment duration. Null values also help in the validation, since a * indicates that intended null values at certain decision points are taking place. On the other hand, if paths show values other than *, it may indicate that activities are performing contrary to the decision rules of the activity. This type of format can also be used to indicate the activity loadings at a specific cycle in the simulation run. A series of printouts of this type is useful in illustrating the dynamic shift that takes place in activities for the specified time segments. This is a means of determining the scheduling of resource requirements over time.

Appendix B (cont)

Table III. Output Display Type A Total System Behavior

Time 400 Activity Name	Student Class	Subject	Branch Zero	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
Activity (xx)	F	1	*	135	10	23	*	*	*	*	*	*
	M		*	417	67	81	*	*	*	*	*	*
	S		*	144	25	21	*	*	*	*	*	*
	F	2	*	111	2	20	*	*	*	*	*	*
	M		*	364	89	78	*	*	*	*	*	*
	S		*	107	20	26	*	*	*	*	*	*
	F	3	*	118	5	22	*	*	*	*	*	*
	M		*	352	85	78	*	*	*	*	*	*
	S		*	98	25	24	*	*	*	*	*	*
	F	4	*	117	8	27	*	*	*	*	*	*
	M		*	346	67	82	*	*	*	*	*	*
	S		*	119	18	18	*	*	*	*	*	*
	F	5	*	110	5	10	*	*	*	*	*	*
	M		*	370	80	71	*	*	*	*	*	*
	S		*	107	23	20	*	*	*	*	*	*

* Null value.

Appendix B (cont)

b. Output Display Type B

A summary of the total time charged against each activity is outlined in Table IV. This summary accompanies each Type A summary. The time totals are functions of the number of passes through the specified activity given on Output Display Type A. Average times spent in each activity for each class category and subject can be calculated from the two listings. The Type A summary shows a total of (135 + 10 + 23) = 168 fast students who passed through activity (xx) for subject one. The total time generated by these 168 students for this category was 840 cycles as shown by Display Type B. The average cycle time spent in the activity per pass was 840/168 or 5 cycles per pass.

c. Output Display Type C

A frequency table of the format illustrated in Table V expresses the ranges and use of any recorded variables or of any function of a set of recorded variables. Since activity number is a recorded variable, it is possible to express the total number of passes for an activity by the individual student in a summary table which has been accumulating the particular events over time from the input tape. The same type of summary may be applied to any variable. Normally we wish to observe student behavior. Summaries are accumulated by treating student numbers as the dependent variable. Thus a summary table may provide the activity range for each student in the model or the time when he has completed a set sequence or unit of activities. The first case would break down the total number of passes for all students in an activity to the frequency range and use by individual students in the model. The illustration given in Table V indicates the frequency distribution for the 168 passes for fast students, 565 passes for medium students, and 190 passes for slow students as shown in activity (xx) subject one on Output Display Type A. Thus it is noted that the use of this particular activity by individual fast students ranged from two passes per student to 13 passes per student. The total 168 passes were generated by the sum of students in column F (19 students). Thus the arithmetic mean for the number of passes by fast students in this category is 168/19 or 8.8 passes. Another observation is the difference in ranges for the three classes of students.

The interpretation of the frequency column is dependent on the type of variable one is trying to express. In the case just illustrated, it was the number of passes through activity (xx) in subject one. A table in the program may provide the cycle time when individual students completed specified units of activities. Thus a frequency table can be generated which shows the range of cycle times for students to complete unit (x) of subject (x).

Appendix B (cont)

Table IV. Output Display Type B
Total Time Spent at Activity

Activity Name	Subject	Class Track F	M	S
Activity (xx)	1	840	4597	1935
	2	665	4250	1343
	3	725	4095	1475
	4	770	3960	1502
	5	642	4144	1548

Table V. Output Display Type C
Frequency Table Format

Variable Name	Frequency	Class Track F	M	S
Activity (xx)	2	1	*	*
Subject 1	3	3	*	*
	8	5	*	*
	11	5	3	*
	12	3	4	*
	13	2	8	*
	14	*	9	
	17	*	7	1
	20	*	3	*
	25	*	3	2
	32	*	*	1
	38	*	*	1
	53	*	*	1

Appendix B (cont)

The generation of the frequency type format is a standard subroutine in program SIMLIST. The type of summary to provide for the frequency format subroutine depends on the type of measure which the model user wishes to introduce for helping in his analysis of the simulation run. Thus we have treated the SIMLIST program as a tool for our analysis, and its capabilities grow as new ideas of measuring the model behavior are introduced.

2. Program STRACE

The complete history of student performance in the model is output by program STRACE. Presently, as many as 10 students can be tracked simultaneously. Cards are input to the program defining the student numbers to be traced. These numbers are compared with the student numbers of all recorded activities on the input tape. When matched, the recorded information of that line is output on the printer. The activity number is translated to an activity name and also a 16-character message for a verbal description of the activity taking place. A listing of a student trace is given in Table VI. The needs of the program then are as follows:

- The event tape produced by the simulation run.
- Type S cards providing student numbers to be traced (maximum of 10).

Column 1	S
Column 9-16	Student number

- Type M cards providing activity names and verbal description.

Column	M
Column 3-4	Activity number
Column 9-16	Activity name
Column 17-32	Verbal description

G. PLANS FOR THE FUTURE

A simulation vehicle was constructed which is capable of producing simulation models for the five schools selected in our study. The initial program objectives outlined in Paragraph B, above, have been accomplished. Each of the design studies for the schools introduced new capabilities into the general

Appendix B (cont)

Table VI. History Trace of Student Through Study Package

Student	Class	Subject	Activity	Branch	Time	Description
7	3	3	ASG WORK	1	46	Assign work help or assess
7	3	3	ASG I GR	2	47	Assign individual or group
7	3	3	IND WORK	1	48	Individual work
7	3	2	ASG W,H,A	1	56	Assign work help or assess
7	3	2	ASG I GR	2	57	Assign individual or group
7	3	2	IND WORK	1	58	Individual work
7	3	5	ASG W,H,A	1	66	Assign work help or assess
7	3	5	ASG I GR	2	67	Assign individual or group
7	3	5	IND WORK	1	68	Individual work
7	3	1	ASG W,H,A	1	76	Assign work help or assess
7	3	1	ASG I GR	2	77	Assign individual or group
7	3	1	IND WORK	1	78	Individual work
7	3	4	ASG W,H,A	3	86	Assign work help or assess
7	3	4	REQ GAS	1	87	File request for group assess
7	3	3	ASG W,H,A	1	88	Assign work help or assess
7	3	3	ASG I GR	2	89	Assign individual or group
7	3	3	IND WORK	1	90	Individual work

Note: Listing continues in above format for all activities for the student.

Appendix B (cont)

simulation vehicle. This continuous introduction and implementation of ideas is an ongoing process toward the perfection of a general simulation vehicle. It is hoped that future simulation studies will continue this growth process.

To date, necessary resources have been assumed to be available for all activities of the vehicle. Although this may be a means of predicting resource demand for activities when the system is allowed to operate without resource constraint, it does not give a valid picture of the operation of the system when decisions are based on the nonavailability of resources. Future capability in this area is necessary and anticipated.

As certain functions of the vehicle design become more general to the vehicle, the need exists to preset the parameters necessary for the general expression via input communication. This has been accomplished for decision rules regarding time and path at the activity level. Other parameters such as defining activities for group mode, group size requirements, assigning rates of progress to students, etc., are preset by the program. The decision on what functions to control via input should be based on our experience in using the vehicle for the simulation studies. There is no need to provide input control for those parameters which do not change from run to run. However, our experience has indicated that better control should be provided for the operation of certain processes of the vehicle. For example, the vehicle has the capability of providing group formations as outlined in Paragraph D,4,c, above. The operation of this process may not be desired for a specific simulation study. Thus we should control the operation or nonoperation of some of these processes via input.

The growth of the computer industry in providing hardware and software capabilities in a time-sharing environment suggests the advisability of moving the simulation vehicle in this direction. As the name implies, a time-sharing system allows many users to have access to a computer which operates several programs under the control of a scheduling supervisor. Users communicate with the various programs via an input console or typewriter. A combination of several consoles may serve as control stations for the same program. System Development Corporation is implementing a time-sharing system for its IBM S/360 computer. The following advantages are immediately realized by using the simulation vehicle with this type of system:

- School models may be constructed on line by defining the activities for the simulation vehicle to operate through a teletype input.
- Components of the total model configuration can be simulated and analyzed for the purpose of suggesting design modifications.

Appendix B (cont)

- Immediate feedback of simulation results is available through teletype printout or cathode ray tube (CRT) displays.
- An input console may serve as the execution of an activity itself and thus can be used to train administrators in understanding the effects of their decisions on the system.
- A time-sharing mode of operation is one which may be feasible for meeting the data processing requirements of schools in the future.

APPENDIX B, ATTACHMENT 1

TABLE AND ITEM DESCRIPTIONS

Appendix B, Attachment 1

The following table and item descriptions define the primary data base for the simulation vehicle. The bit structure of all items within the tables is found in Figure 1.

Table	Item	Description
CATEGORY		A 10-word table used by the GENERATE subroutine in assigning class codes to students according to a defined distribution.
	PCAT	A distribution percentage for determining the selection of class code on a random selection.
	CAT	The class code assigned for the distribution (PCAT) selected.
CNTGNCY		A 500-word table ordered by student line of location and tested by activities in forcing decision paths based on previous student behavior.
	SX1-SX10	Defines 10 contingency items which can be individually tested for each student. Values usually contain path numbers assigned at a previous activity in the model for the student.
	TWORK	Contains the number of cycles assigned by an activity to accomplish its function for the student.
	GRRQ	Contains a code 1, 2, or 3 for a group assess, group help, or group study request on file for this line of location.
EVENT'TIME		A 500-word table ordered by student line of location containing a time line definition for activity QLOC in table STUD'LOC. Refer to Section D,3,b.
	DO	The first bit of the time line definition. It is tested by the Resource Allocation Processor to set up the next activity for cycle i + 1 and tested by the Activity Processor in cycle i + 1 for branching to the new activity.

Appendix B, Attachment 1 (cont)

Table	Item	Description
	EVENT	Refers to the complete time line for the line of location being processed.
GAS'BUFF		A 500-word request buffer containing all requests for group assess for processing by the group assess simulator.
	GAASS	A bit which, when set, indicates the group assess request has met the qualifying criteria for a group. It is used internally in the group assess simulator.
	GASUB	The subject number of the group assess request on file.
	GAUN	The unit number of the group assess request on file.
	GACYC	Contain the number of cycles the group assess request has been on file without qualifying for the group assess activity.
	GADO	Contains a measure of the student progress at the time of filing the group assess request.
	GASTU	The student number of the group assess request on file.
GAS'REQ		A 10-word table set and used by the group assess simulator for determining the number of group formations.
	GASUBA	The number of group assess requests in the group assess buffer for subject 1.
	GASUBB	Same as GASUBA but for subject 2.
	GASUBC	Same as GASUBA but for subject 3.
	GASUBD	Same as GASUBA but for subject 4.
	GASUBE	Same as GASUBA but for subject 5.

Appendix B, Attachment 1 (cont)

Table	Item	Description
	GAFULA	The number of groups which can be formed for group assess requests in subject 1 from criteria expressed in the group assess simulator.
	GAFULB	Same as GAFULA but for subject 2.
	GAFULC	Same as GAFULA but for subject 3.
	GAFULD	Same as GAFULA but for subject 4.
	GAFULE	Same as GAFULA but for subject 5.
GHS'BUFF		All definitions are the same as for items defined for table GAS'BUFF.
GHS'REQ		All definitions are the same as for items defined for table GAS'REQ.
GRASES		A five-word table containing parameters used by the group assess simulator.
	GASZ	Defines the group size for subjects 1-5.
	GAMAX	Define the maximum number of cycles to allow a group request to remain on file without scheduling the request.
GRHELP		All definitions are the same as for items defined for table GRASES.
GRSTUDY		All definitions are the same as for items defined for table GRASES.
GSS'BUFF		All definitions are the same as for items defined for table GAS'BUFF.
GSS'REQ		All definitions are the same as for items defined for table GAS'REQ.
NUMSEL		A 10-word table used by the next DO selector subroutine in determining the selection of lines of location.

Appendix B, Attachment 1 (cont)

Table	Item	Description
	DECN	A number used for indexing the proper line of location for an activity.
	DECP	A distribution percentage for determining the selection of item DECN.
SPLIT'VAL		Contains parameters necessary for the decision rules for each activity when based on random selection.
	QT	Activity number which will be set in item NACT for next activity.
	PX	Percentage distribution for random selection of values QT, TX, and VX.
	TX	Time to be assigned to activity (QLOC).
	VX	Path number which leads to activity QT.
START'TIME		A 10-word table containing parameters necessary for initializing students into the system.
	PST	A percentage distribution for selection of start time (STRT).
	STRT	A time expressed in model cycle time when a student will become active in the system.
START'UNIT		A 10-word table containing parameters necessary initializing students in a specific unit of study.
	SUNIT	The unit number in which to initialize the student.
	PUNIT	A distribution percentage for determining the selection of SUNIT.
STATUS		A 60-word table containing the status of each activity in the model in terms of capacity and resource.

Appendix B, Attachment 1 (cont)

Table	Item	Description
	QMAX	The maximum number of students allowed in activity (xx) where (xx) = 1-60.
	QREQ	The minimum number of students allowed in activity (xx) where (xx) = 1-60.
	QCNT	The actual number of students engaged in activity (xx) where (xx) = 1-60.
STUD'IND		A 100-word table indicating the status of students relative to group requests.
	GRTRY	Incremented by one each time a student cannot enter subroutine NDS because all lines of location for the student have group requests on file.
	GRNUM	The number of group requests that student (xx) has on file.
	GRAS	Set = 1 when student is actively engaged in a group activity and therefore cannot be scheduled immediately for another group activity.
STUD'LOC		A 500-word table ordered by student line of location which defines the logical and physical status of each student.
	CLS	Class code assigned to student.
	INTER	Set to line of location number which was interrupted when group request was scheduled.
	UNIT	Unit number of student.
	DRATE	A number used to determine the achievement rate of student.
	DTIME	A number used as a measure of actual student achievement.
	NACT	The next activity number to which the student will be assigned.

Appendix B, Attachment 1 (cont)

Table	Item	Description
	QLOC	The present activity in which the student is logically and/or physically active.
	CONT	Defines student status as continue.
	GO	Defines student status as go.
	PRRTY	Defines student status as priority.
	MKRDY	Defines student status as make ready.
	INTRM	Defines student status as interim.
	DEFER	Defines student status as deferred.
	SUSP	Defines student status as suspended.
	DACTVE	Defines student status as deactive.
	ACTVE	Defines student status as active or dormant.
STUD'TAB		Contains activity record of students for recording.
	CLA	Class code of student.
	SUBJ	Subject number of student.
	SSEQ	Model cycle time when activity (ACT) is initiated.
	TTDO	Duration time in cycles assigned to activity (ACT).
	ACT	Activity number initiated at time (SSEQ).
	UN	Unit number of student.
	RESP	Decision path chosen from activity ACT.
	STUD	Student number.

Appendix B, Attachment 1 (cont)

The following item descriptions are simple items referred to in this chapter. Other simple items are used by the program for internal processing and not included below.

Item	Description
ACTIVE	Set up by the Activity Processor with the activity number of the activity currently being processed for a line of location.
CLASS	Set by the Activity Processor with the class code of the student being processed.
GAACT	Contains an activity number which is defined as a group assess activity and tested by the Resource Allocation Processor.
GATIME	Contains the model cycle time when the group assess simulator is to operate. It is incremented after the operation of the group assess simulator.
GHACT	Same as GAACT but for group help.
GHTIME	Same as GATIME but for group help.
GSACT	Same as GAACT but for group study.
GSTIME	Same as GATIME but for group study.
KCYCLE	Contains an interval of time in cycles which is used to set the frequency of the group simulator operations.
NSTUD	Set prior to the simulator run and contains the maximum number of students to be processed in the simulation.
STUDENT	Set by the Activity Processor with the student number to be associated with the line of location being processed.

Appendix B, Attachment 1 (cont)

Item	Description
SUBJECT	Set by the Activity Processor with the subject number for which the student is being processed.
TIME	Incremented by one for each complete Activity Processor operation and contains the model elapsed time in cycles.
TMAX	Preset by the program and containing the maximum number of cycles to allow in the simulation.

APPENDIX C

SYSTEM ANALYSIS AND COMPUTER SIMULATION OF THE CONTINUOUS PROGRESS SCHOOL AT BRIGHAM YOUNG UNIVERSITY LABORATORY SCHOOL

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Appendix C

A. INTRODUCTION

In 1959, Dr. Edwin Read, who at that time was Director of the Brigham Young University School,* developed a plan for a continuous progress school and introduced it into selected parts of the laboratory's school curriculum.

In general, the procedures used in the continuous progress plan are designed to make instruction more individualized. Study guides are prepared for each student working in a course. The study guides contain descriptions of all the units of study in the course, the objectives of each unit, and instructions to the student for work on the course. Students work at their own rate of speed. Self-expectancies for rate of progress and level of achievement are set by each student through consultation with the counselors. Students work in an individual mode unless they need help from the teacher or are ready for a group discussion or special presentation by either the teacher or special instructional media.

When students require help from the teacher, they fill out a request form. The requests are collected and analyzed at the end of the day by the teachers. The students meet with the teacher in small groups on following days. The groups are made up of students who have a common problem in the course.

When a student has completed a unit of work, he files a request to take a unit test. The test requests are collected at the end of the day, and the teacher schedules the student to go to the testing room the next day to take the unit test under supervision of the test clerk. If the student does not pass the test, he does additional work on the course and schedules a retest later. He keeps trying until he passes the test at the level of achievement individually established for him.

The system analysis which this report describes was performed from the fall of 1963 to the winter of 1965. When data were collected in 1963-1964, the following courses were developing and implementing procedures for continuous progress operation: Mathematics, grades 7 through 12; Language Arts, grades 10 through 12; Spanish, grades 10 through 12; and Typing.

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Appendix C (cont)

B. PROBLEM

Brigham Young University Laboratory School was the first school to be studied in connection with the present project. Therefore, the problems were: (1) to explore the use of system analysis and computer simulation techniques for studying educational organization; and (2) to develop procedures to be used in the analyses of other schools. The study was initially oriented to analyze the total operation of the school system. The intent was to study all courses given and all the functions offered such as counseling, administration, and instruction.

The work that was done is reported as three separate studies. The studies are presented in the chronological order that they were performed. The first study was concerned with developing written specifications for a future continuous progress school. The second study involved the development of a computer simulation model of the ninth-grade algebra course at the Brigham Young University Laboratory School. The third study involved simulating the school on the computer to explore the implications of autonomous student scheduling procedures for schools using a continuous progress plan.

C. SYSTEM DESIGN OF A FUTURE CONTINUOUS PROGRESS SCHOOL

1. Problem

The purpose of this study was to develop a system design for an ideal continuous progress school of the future that would make wide application of advanced information processing technology.

2. Method

Data were collected from the director, teachers, and counselors at the school regarding present procedures and procedures that were planned for the future. Project personnel constructed detailed flow charts of these procedures, analyzed them, and developed additional design ideas for improving the future system. New flow charts with accompanying verbal descriptions were developed to incorporate the design additions.

Three system design documents were produced in this part of the study (References 19, 20 and 21). These documents present detailed specifications of procedures for the operation of a continuous progress school for the future.

Appendix C (cont)

3. Results

The first design document concentrated on the general organization of the school. A description was given of the flow of information between the various subsystems such as administration and counseling, the general procedures for processing students through the system, and a centralized school information processing system including some of its functions. In addition, the design of the procedures for preregistration, registration, and progress through the language arts course was described in detail.

The following functions of an information processing center were identified:

- After the student applies and is tested, the test scores and application data are processed by the information processing center to produce tentative achievement expectancies for each student. Two expectancies are set for each student--one for rate of progress and one for level of achievement. These data are then used by the counselors in helping the student set his own expectancies.
- After students have registered, the Information Processing Center processes the registration data and schedules students, teachers, space and equipment.
- The Information Processing Center constructs and reports summaries of student data that can be used by the school staff in planning.
- Data on current and planned use of resources, and data about existing and planned acquisition of resources are analyzed by the Information Processing Center, and short- and long-range staff, space, supply, and equipment needs are developed.
- The Information Processing Center develops and reports summaries periodically, such as the number of students registering in any specific week for Algebra II for the mathematics department.
- The Information Processing Center is responsible for surveillance and monitoring of student performance.

The first five information processing functions are described at length in Reference (1). The sixth function--surveillance of student performance--is discussed in Reference (20).

The monitoring function was referred to as the "Surveillance and Detection System" in Reference (20). Later during the project this name was changed to "Instructional Management Information System."

Appendix C (cont)

The primary objective of the monitoring function in the "ideal" school is to collect and analyze extensive data on student performance. These data are divided into four categories: first, dates that students perform various activities, such as completing reading assignments, reports, projects, tests, courses, conferences with teachers, conferences with counselors, and participation in academic and nonacademic group activities; second, the scores on aptitude tests, achievement tests, interests tests, personality tests, and course tests; third, perceptions of the students by the student himself and by teachers and counselors; and fourth, data about student plans and goals such as vocational goals, course programs, and expectancy levels.

The analysis of these data is oriented toward identifying students who might be experiencing difficulty or who need help. The system could provide information to students and teachers on such things as whether or not students were behind in their rate of progress in courses, assignments that were not completed on time, decline in performance in a number of courses, lack of contact between teacher and student, lack of contact between individual students and other students, discrepancy of student's behavior with his stated interests and goals, etc.

The surveillance system offers a number of advantages. It frees the teacher from a large portion of the very time-consuming task of keeping and analyzing an up-to-date record of every student's performance. It helps the teacher plan his time more efficiently by informing him of those students who might be most in need of his time. It helps make teachers more perceptive of the student as a person in the context of his total program rather than in relationship to only a single course. And, it provides the student with more information about himself that he can use in decision-making.

Reference (21) describes the design of the IMC (Instructional Materials Center)--a center which combines the functions of a library, bookstore, audiovisual center, and materials development area. Some of these functions are substantially different in a continuous progress school than in a traditional school. For example, all books, both library and test, are circulated via the IMC. This is necessary because the continuous progress plan permits students to progress at varying rates through the curriculum, so while one student may begin geometry on the first day of school and finish on the last day, another student may begin on the 23rd day of school and finish on the 86th, and still another student may begin on the 23rd day and not finish until the 75th day of the ensuing year. Thus, all books must be available on a variable time basis.

In the continuous progress school, audiovisual equipment and materials are utilized on the basis of student rather than faculty request. When an individual student is ready for a particular film, tape, or other audiovisual presentation, he requests it. While this procedure permits much greater flexibility, it also places much greater demands on equipment, materials, and scheduling. Arrangements must be made to meet these increased demands.

Appendix C (cont)

Four facets of the IMC were portrayed and described in Reference (21). These are: (1) acquisition and disposition of purchasable items; (2) acquisition of new books and equipment; (3) circulation of books, differing from the traditional form because of the continuous progress nature of the school; and (4) scheduling and use of IMC facilities, also differing from the traditional form because of the continuous progress nature of the school. The design calls for the Information Processing Center to schedule use of the Instructional Materials Center.

4. Implications of the Results of the Study

The implications of this study are discussed below:

a. Implications Concerning the Analysis

In this study, three problems in methodology became apparent. The design documents did not differentiate between the procedures that are currently in use at Brigham Young University and the procedures that are offered as design. This made it impossible for any reader other than the personnel at the laboratory school to know what had been achieved to date. It was also impossible to identify prospective problems in the existing operations. A second problem was that the scope of the analysis and design was too ambitious for the resources of the project. The attempt to provide analysis and design recommendations for the total school operation was impossible with the time and manpower resources that were available for this project. Two decisions were made on the basis of this finding: (1) In the analysis and design studies that follow (Appendixes D through G), a document describing the existing system was written that was separate from a document describing the analysis and design recommendations; and (2) a specific area of the school operation (such as a single course in which some innovation was being developed) was selected for intensive analysis rather than attempting to describe the total operation of the school. Implications for the operation of the entire school were drawn from the specific analyses.

b. Implications of the Design Recommendations for the Objectives of the General Project

(1) Implications for Personnel Roles

Problem: If the design recommendations for an information processing center are implemented, there will be a marked affect on the roles of teachers and counselors.

Appendix C (cont)

Solutions: Teachers and counselors will have to be trained as follows:

- They will have to learn to perceive themselves as playing functional roles as part of a man-machine system.
- They will have to learn not only what information is available, but also how to obtain and use that information.
- They will have to learn how to make their objectives, criteria for evaluation, and procedures explicit.
- They will be required to participate in developing the system. That is, they will have to participate in (1) collecting data about the system's operation; (2) making periodic evaluations of system performance; and (3) planning design changes.
- They will have to change their attitude toward the method of controlling and monitoring students. They must learn to trust the operation of the information processing system to track student progress and to alert them if students need their attention.
- Finally, if they are to operate in a system where scheduling routines function to optimize the use of resources, they will have to adjust to having their time scheduled on a day-to-day basis.

(2) Implications of Results Regarding the Effects of Media on Student Instruction

Problem: The use of the Continuous Progress Plan can result in isolation of students who do well from the teacher. The students could possibly go through an entire course without contacting the teacher.

Solution: The use of an information processing system with a tracking function would provide a means of keeping track of students who have not been in contact with teachers for long periods of time. The system could be designed to warn teachers when too much time had elapsed between student/teacher interviews.

Appendix C (cont)

(3) Implications of the Results of Using Information Processing Techniques

Problem: The individualized procedures of the continuous progress plan greatly increases the amount of information processing that is required. Much personnel time could be wasted in trying to collect and handle the information that is required.

Solution: An information processing system should be developed that has the functions outlined in Section C, 3 of this appendix.

(4) Implications of the Results for the Use of Space

Problem: Designing an Information Processing Center necessitates defining the type of equipment and the use of space for the central processing equipment and for peripheral input/output equipment.

Solution: The solution to this problem deserves much further study; however, the recent development of time-sharing capabilities for computers indicates that schools will be able to afford to use the powerful resources of time-sharing computers. These systems could perform all the information processing functions suggested in this report. The school will probably be able to rent such services. The input/output equipment could be located in the school and could be connected by telephone to a central processing unit outside the school. Such a situation is described in Appendix H of the report. A teletype in a Palo Alto Junior High School was controlled by a computer at System Development Corporation in Santa Monica. On-line educational planning interviews with students were conducted.

D. SIMULATION OF THE NINTH-GRADE ALGEBRA COURSE AT BRIGHAM YOUNG UNIVERSITY LABORATORY SCHOOL

1. Problem

The problem in this portion of the study was to explore the use of the computer simulation capability and to develop procedures for validating models.

2. Method

A model for computer simulation of the ninth-grade algebra course at the school was formulated (Reference 12). The model was designed to predict how students would be distributed with regard to their progress at various points in time during the operation of the course.

Appendix C (cont)

The model was based upon descriptions by the teachers of the procedures used in the course and of the behavior of students in the course. A simulated population consisting of 19 fast students, 19 slow students, and 62 medium students, was defined. The fast students were defined as those able to complete the course in 80 hours. The medium students were characterized as those doing the work in 100 hours, and the slow students were characterized as doing the work in 120 hours. It was assumed that all three groups of students had the same amount of work to do in the course.

Different procedures were defined for simulating the behavior of each of the three groups in the course. The distribution rules for the three groups were that after each hour of work the students would decide either to get help, to take a test, or to continue working in an individual mode. If the students decided to continue work they could do so; or the teachers might assign them to take a test or to get help before continuing with their work.

Table I shows the proportions of students that were to branch after each hour of individual work. Two branch points were included in the model to allow the simulation of two types of decision. In Branch 1, the decision by the student is simulated. In Branch 2, a decision by the school can be simulated. In other words, in the case of the fast students, 70% decided to continue work, but 5% of them were simulated as responding to a directive to take a test at Branch 2.

3. Results

Figure 1 shows a comparison of data obtained from the simulated run with data obtained from real students in the algebra course. The data shows the distribution for the slow group. The slow students from the real course were defined as the lowest 20% in terms of their rate of progress through the course. Each line shows the distribution of the students in terms of the hours of work that they have completed in the course at particular times during the course. The total course takes approximately 120 hours for the average student to finish. The base line shows the number of hours from 0 to 120. Four distributions were obtained for each of the groups. The second, fourth, sixth, and eighth lines show the distribution for real students on October 2, December 1, February 1, and April 1, respectively.

The first, third, fifth, and seventh lines show the distribution of the students from the simulated run at comparable time periods.

Appendix C (cont)

Table I. Proportions for Distributing Fast, Medium and Slow Students at Decision Points in the Simulation Model for Ninth-Grade Algebra Continuous Progress Course

(Column 1) Groups	(Column 2) Activities from Branch 1	(Column 3) Distribution Proportions Branch 1	(Column 4) Activities from Branch 2	(Column 5) Distribution Proportions Branch 2
Fast	Continue Work	80%	(Continue Work)	95%
			(Get Help)	0%
			(Take Test)	5%
	Get Help	5%		
	Take Test	15%		
Medium	Continue Work	70%	(Continue Work)	80%
			(Get Help)	10%
			(Take Test)	10%
	Get Help	15%		
	Take Test	15%		
Slow	Continue Work	70%	(Continue Work)	50%
			(Get Help)	25%
			(Take Test)	25%
	Get Help	15%		
	Take Test	15%		

NOTES: Column 1 shows the groups. Column 2 shows the activities that students can be branched to at Branch 1. Column 3 shows the proportions used at Branch 1. Column 4 shows the activities that could be selected at Branch 2. Column 5 shows the proportions used for branching the three groups at Branch 2.

Appendix C (cont)

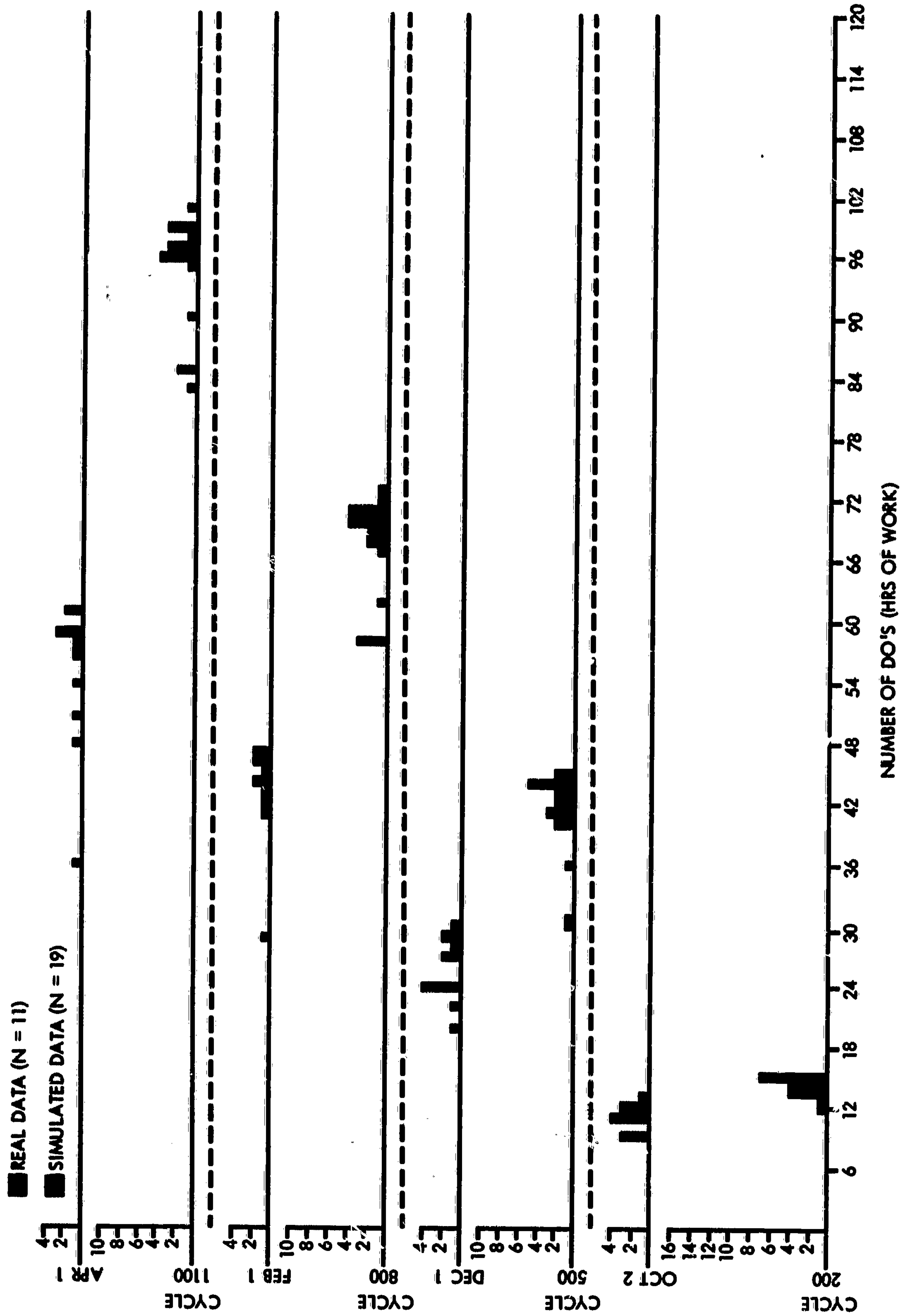

Figure 1. Comparison of Simulated Data with Real Data for Students in Algebra Continuous Progress Course in Terms of Temporal Progress (Slow Group)

Appendix C (cont)

Two interesting hypotheses were suggested by the comparison. The rate of progress that was modeled for the simulated group appears to be in error because the real students progress at a slower rate through the course. Therefore the model should be changed to conform more accurately to the real data. However, the question of how the model should be changed is not as simple as it may first appear. The simulation did not include scheduling the students into groups for help; in the real situation such grouping did occur.

When the waiting or queueing for the scheduling help is defined in the simulation, the rate of progress of the simulated group may correspond more closely to the progress of the real students. A simple adjustment of the rate of progress in the model would provide the same rate, but possibly for the wrong reason.

A second interesting hypothesis is related to the shapes of distribution curves for the two groups. The shapes are very similar. Both the real and simulated data change from an approximate normal distribution to a rectangular shape, and the spread of the two distributions increases rapidly over time. These data led to the hypothesis that the stress on the system imposed by the slow students would become increasingly severe as time progresses. Since it was assumed that the slow students would require more help, and since the data indicates that the spread becomes greater through time, the number of groups to be scheduled for the slow students also would become greater as time progresses. These findings are supported by the events in the real situation. Almost all of the available teacher time is spent with the slow students. In addition, the number of groups has increased considerably and the number of students in each group has decreased. The average size of the groups is two students.

Two schools in two different parts of the country have independently been experimenting with the continuous progress plan for the past four years--Brigham Young University Laboratory School and Theodore High School (Appendix E). Both schools have independently decided to place their slowest students back in a lockstep group plan. The analysis of the simulated data indicates that the change in procedure was required as an adjustment to the increased stress on the system. Although the administrative decision may be justified by the explanation that the slow students are not suited to the plan, the simulated data indicate that the resources and the organizational plan have become increasingly unsuited to the slow students.

Figure 2 shows the comparison between the simulated fast group and the real fast group (the fastest 20% in the real Algebra course). The rates of the two groups are comparable, but the distributions are entirely wrong. The simulated

Appendix C (cont)

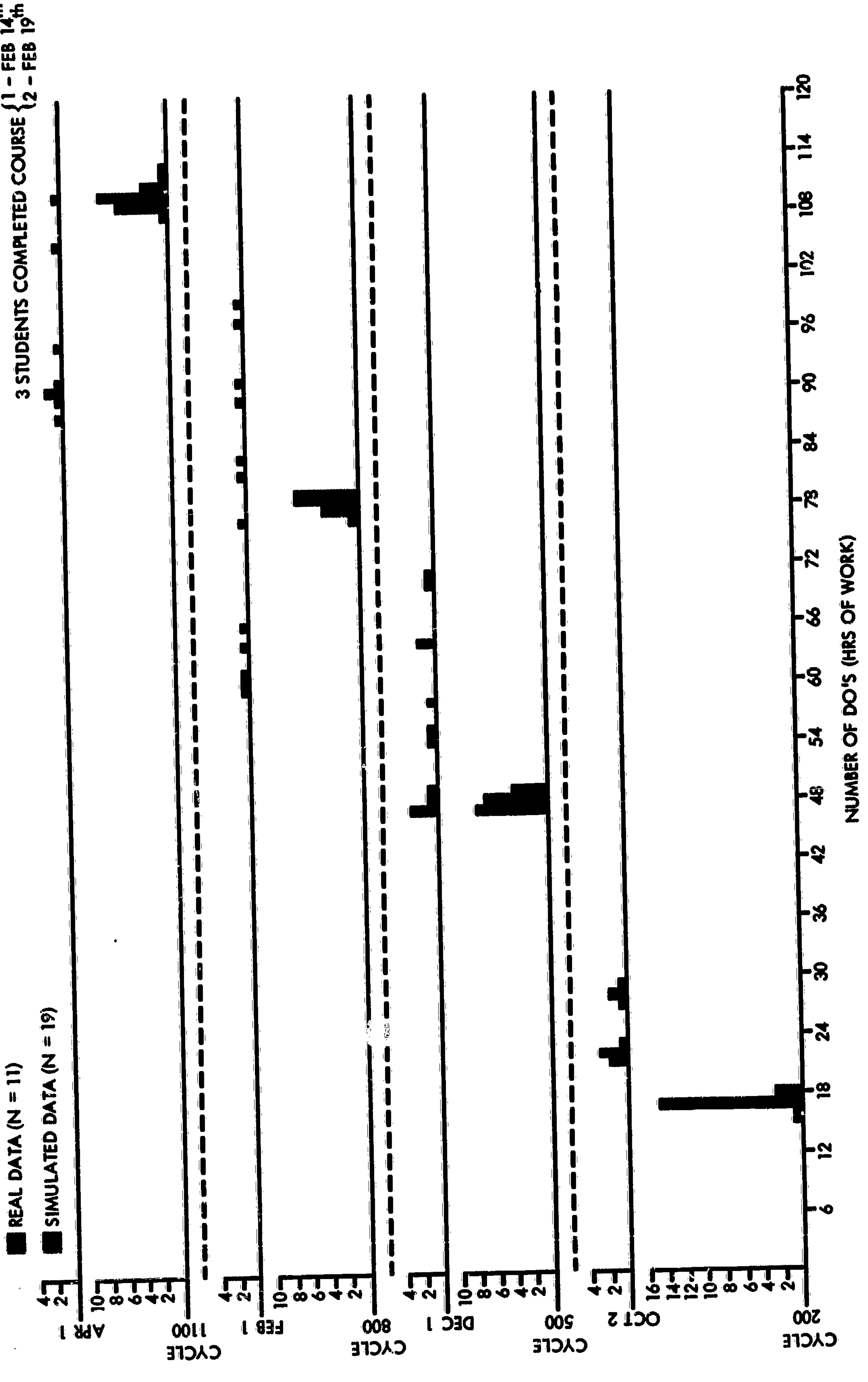

Figure 2. Comparison of Simulated Data with Real Data for Students in Algebra Continuous Progress Course in Terms of Temporal Progress (Fast Group)

Appendix C (cont)

data indicates much greater homogeneity in spread than actually occurred. Although the fast students spent minimal time with the teachers, they did vary markedly in their rate of progress.

The distribution of the total group on February 1 (including the so-called fast, medium, and slow students) was correlated with a number of measures to provide some hypotheses regarding the reasons for the distribution. The measures included the STEP math, reading, and listening scores; an IQ measure; and the average number of frames of homework reported daily. For the total group of 55 students, a significant portion of the variance was accounted for by the combination of intelligence, homework, and STEP listening. Of the three variables, intelligence and homework contributed most heavily to the variance. Analysis of the slow group--although of questionable reliability because of the small sample size--suggests that reading ability contributes heavily to the variance within the slow group, but that it does not contribute to the variance within the medium and fast groups.

4. Implications of the Results

a. Implications for Methodology

This study showed that a more valid model could be obtained by taking greater care to collect descriptive data prior to the simulation. If the detailed data on student progress had been studied prior to constructing the model, the discrepancy between the simulated data and the real data would be minimal. In the descriptions of simulation studies that appear in Appendixes D through G where a model of the existing course was constructed, greater correspondence was achieved between the real and simulated data.

b. Implications for the General Objectives

(1) Implications for Personnel Roles

The widespread distribution of student progress that occurs will cause students to vary markedly in their needs for help from the teacher. Some students will be working on materials at the end of the course at the same time that other students are working on materials near the beginning of the course. Teachers will have to be well prepared over a wide range of the subject-matter if they are to be able to teach

Appendix C (cont)

students in need of help on short notice. The requirement that teachers work with individuals and small groups means that teachers also will have to be able to diagnose learning problems and to develop varied teaching strategies to solve these problems.

(2) Effects of Use Media on Interactions

As students become more and widely distributed in progress, teachers will be pressed to see a larger number of groups. More and more of their time will be spent working with the slower students.

The use of the autonomous scheduling procedures that are described in the study reported in Section E, below, should be considered as a solution to this problem.

(3) Uses of Information-Processing Technology

The wide spread in distribution of student progress indicates that the problem of keeping track of individual students is very difficult. The implementation of an information-processing system for tracking student progress should solve this problem.

(4) Characteristics of Graduating Students

The simulation of student progress through the algebra course suggests that if students are allowed to progress through all courses in this individualized manner, the students will graduate from high school at different times. If this change does occur, it will present a problem at the interface between high school and college.

E. COMPUTER SIMULATION OF AUTONOMOUS SCHEDULING PROCEDURES FOR A CONTINUOUS PROGRESS SCHOOL

1. Problem

Although the continuous progress plan represents a first step in the direction of providing greater individualization in instruction by allowing students to vary their own rate of progress, further steps could be taken in developing plans for individualization in the instructional process. System analysis and

Appendix C (cont)

computer simulation provide a method for developing a plan for changing the school organization further in the direction of individualization. One direction that developments could take would be to break completely away from the lockstep system. The current continuous progress plan allows students to vary their rates of progress, but these students still are assigned to work on their courses at specified times in specified places with other specified students. A change from this direction would be to allow students freedom in the budgeting of their time to individual study. Rather than working on mathematics at a specified time, they could work on mathematics when they want to and for as long as they desire.

The problem in this study was to use system analysis and simulation to develop design ideas for an autonomous student scheduling plan.

2. Method

A model of a continuous progress school with simulated students scheduling themselves autonomously for work in individual study was constructed with the computer simulation capability described in Appendix B.

The model (Reference 15) simulated 100 students who varied in their rates of progress. They were simulated as taking five courses as in a conventional school. During a daily five-hour independent study period students were simulated as randomly selecting a course on which to begin work. If the simulated students needed help or should have taken a test in the course, they were simulated as filing a request for help or test. Then they were simulated as proceeding to work on a second course rather than trying to continue work in the first. If the simulated students were not interrupted in their first course, they moved to a second randomly selected course at the end of the period. The demands for help and testing in each course were based on the same probabilities as those shown in Table II. Thirty days of school operation were simulated.

3. Results

The output data from the simulation were studied to provide estimates of the amount of resources and the kinds of procedures that might be needed to operate the continuous progress plan with autonomous scheduling procedures for students. The results of the simulation were considered in relation to the resource and scheduling demands for individual study, the resource and scheduling demands for getting help from the teachers, and the resource and scheduling requirements for testing.

Appendix C (cont)

Table II. Medians and Ranges of Daily Student-Hours Spent in Individual Study for Courses 1-5 for 100 Students

Courses	Ranges	Medians
1	64-113	78
2	59-94	77
3	59-89	76.5
4	67-95	79
5	59-97	76.5

Appendix C (cont)

The simulation of students working in an individual mode during the five-hour independent study period involved not only the time spent in work at individual study on the five courses, but also the time spent in filing requests for help, in testing, and in changing from work on one course to work on another. Table I shows that the average amount of student time spent in the classes ranged from 62 to 98 student hours. The median amount of time spent in the class was 77. These data indicated that the plan may allow for some cost saving by requiring fewer seats for independent study than the number of students. Analysis of the output data supported the hypothesis that supplying seating capacity for 90% of the student body would probably provide sufficient seating capacity for most of these space demands. If the time spent working in group conferences and in laboratories had been included in the model, the demands for independent study would be even less than 90% of the total number of students.

Table III shows that the demands for help from the teacher in any course varied from 6 to 22 requests a day. The median number of requests for the five courses was 13.

Analysis of the simulated help requests suggested a number of strategies for meeting the help needs. The help requests could be answered in a help and testing period that would begin at the completion of the five-hour independent study period. Table IV shows that under the worse possible conditions, an average of 10 minutes of individual help could be given to each student in a help period lasting for 3 hours and 40 minutes if the teacher/student ratio were 1/100. If it is assumed that the lunch hour would be scheduled on a shift basis during the school day, the total school day would have to be 8 hours, 40 minutes in length on peak days. Under better conditions, with a teacher/student ratio of 1/25 on days of minimum demand for help, each student who asked for help could have an hour of individual attention from a teacher during a two-hour help period. If we assume a teacher/student ratio of 1/50, an average of 20 minutes could be spent with each student who asked for help. Another way of scheduling help would be to limit the average help time for each student to 10 minutes and the total help period to two hours, while varying the number of teachers to be assigned to the help period each day. On days of minimum demand, one teacher could handle the need; on days of maximum demand, two teachers would be required in a two-hour period. If it were desirable to have individual help sessions lasting on the average for 20 minutes, then two teachers could handle the requests on minimum days and four teachers could handle the requests on maximum days.

Appendix C (cont)

Table III. Medians and Ranges of Help Requests (Based on five courses for 30 days of simulated operation)

Courses	Ranges	Median
1	6-22	13
2	10-21	14
3	10-20	14
4	6-22	12
5	8-20	13

Appendix C (cont)

Table IV. Ranges of Time Required for Three Teacher/Student Ratios
(Based on the assumption that each student received an average of 10 minutes of individual help)

Courses	Ranges of Time for Help; Teacher/Student Ratio = 1/100	Ranges of Time for Help; Teacher/Student Ratio = 1/50	Ranges of Time for Help; Teacher/Student Ratio = 1/25
1	1 hr - 3 hr, 40 min	30 min - 1 hr, 50 min	15 min - 55 min
2	1 hr, 40 min - 3 hr, 30 min	50 min - 1 hr, 45 min	25 min - 53 min
3	1 hr, 40 min - 3 hr, 20 min	50 min - 1 hr, 40 min	25 min - 50 min
4	1 hr - 3 hr, 40 min	30 min - 1 hr, 50 min	15 min - 55 min
5	1 hr, 20 min - 3 hr, 20 min	40 min - 1 hr, 40 min	20 min - 50 min

Appendix C (Cont)

Teacher assignments would have to be based upon an analysis of the requests that were filed each day. If the procedures for filing help requests included well-defined descriptions of the particular needs of each student, daily teacher assignments could be made more efficiently. If the availability of a computer-based instructional management information system is assumed, it would be possible to develop sophisticated computer programs for analyzing the requests filed by students to determine the number of teachers required each day. Such a program could include rules for estimating the length of time required for each student. If teachers could be identified in terms of subject-matter strengths and weaknesses, and in terms of their ability to work with different students, the program could take these values into consideration. In addition, the program also could make up efficient student schedules. Such a student scheduling program could take into consideration the total needs for help and assessment of each student every day and could schedule students to teaching spaces so that students would be available in queue when the teachers were ready for them.

Analysis of the demands for testing indicated that the needs could range from 9 to 29 requests in any specific course on any given day. The median number of daily requests would be 17. Since each student in a course might require a different test, the management of testing might be difficult. The data indicates that it would be desirable to have one testing space available for each course. Although one person might be able to monitor testing of the total group, the problem of administering as many as 29 different tests at one time might be extremely difficult. If the tests did not exceed 30 minutes in length, test administration could be extremely difficult. Again if the tests did not exceed 30 minutes in length, there could be two testing sessions on days that the demand approaches the maximum. With two 30-minute test periods, and with maximum demand for assessment, the size of each testing group would be about 15. If one testing person could handle 15 students at a time, half of the time he could handle all of the testing required. If the requests for assessment that have accumulated through the first four hours of individual study were collected by the persons responsible for testing, the appropriate test materials could be selected and arranged for most of the students in advance. It would also be extremely important to develop written instructions for each test that are clear and require minimum help from the testing personnel. With very well developed procedures for testing, one person could probably administer and monitor as many as 15 different tests at one time. If it is assumed that the testing periods occur during the same period of time in the day as the help period, the effects on student and teacher scheduling must be considered. Nonprofessionals could be used for test administration to maximize the availability of teachers for individual help periods.

Appendix C (Cont)

4. Implications of the Results

a. Methodology

This study was useful for expanding the simulation capability and for exploring its uses in design. The use of the simulation capability in this study, especially the involvement in the analysis of the output data, created a strong subjective feeling for the validity of the simulated procedures. The detailed output data seemed to the analyst to give a great deal more structure to the model than was experienced prior to viewing the results of simulation. If this effect of vividness and of face validity is generally experienced by others who use the simulation capability, two implications should be considered. The experience of working with a simulated model of a plan for innovation may lead to a much increased readiness to implement innovation. The confidence that one understands the plan and can anticipate the consequences may do much to reduce resistance to try the innovations. However, if further use of the model does support this hypothesis, caution must be exercised in its use. The feeling that a plan is valid does not necessarily mean that such is the case.

b. Five Objectives

(1) Personnel Roles

If autonomous scheduling procedures like those hypothesized in the simulation model were implemented, the roles of the teachers would change radically. The changes are as follows:

- Teachers would not meet with classes of students for specified time periods.
- Teachers would probably stay in their offices during a large part of the five-hour individual study time.
- Students would come to the carrel areas for each course. These carrels would be in view of the teacher's office.
- Teachers would work on planning, meet with small groups, supervise laboratory work and monitor students in the carrel area during the five-hour individual study period.

Appendix C (cont)

- Students would determine the times that they would go to the learning areas associated with particular subjects.
- Teachers would be available in their teaching areas during the afternoon help period.
- Teachers would have a list of the names of students who need help so that they could plan their time.
- Test clerks would be responsible for administering tests.

(2) Effects of Use of Media on Interactions

Simulation of autonomous scheduling procedures provide some support for the hypothesis that each student who needed help could receive it on an individual basis on the day that the need occurred.

(3) Uses of Information Processing Technology

The flexible procedure of allowing students to schedule their time for independent study would make it impossible to know when students would require various resources.

Automated scheduling procedures would have to be developed that would schedule teachers, students, space, and equipment on a day-to-day basis so that the use of resources would be optimally allocated and so that the individual needs of students could be given adequate consideration in the scheduling.

(4) Implications for Space

In a plan that allows students freedom to schedule their use of time in independent study, the amount of space required for independent study is difficult to predict.

However, simulation of autonomous scheduling procedures indicated that a conservative rule would be to plan for enough independent study seating space for 90% of the student population.

Appendix C (cont)

Another question that is raised is whether the independent study space should be arranged so that all of the carrels for independent study are located in one large central area, where monitors or teachers are available to the students, or should the carrels be located in departmental areas near the teacher? Another way of posing this problem is to ask, "Should the resources be arranged around the student or around the teacher?"

The answer to this question is difficult and cannot be answered definitively at present. However, the fact that some saving could be achieved by not providing a carrel for every student, and the fact that the teacher is one of the most limited and important resources in a school argues in favor of locating the carrels around the teachers rather than locating the teachers in a central carrel area. If enough carrels were located near the teachers' station, the teachers could work at their desk while monitoring students in the carrels. If teachers had to spend time going to a separate carrel area to monitor students, there would be a loss of valuable teacher time. A rule that might provide a reasonable estimate for planning the number of carrels that should be available for a course of study would be to divide the total number of students assigned to the course by the average number of courses that the students are taking. Thus, if 100 students were assigned to ninth-grade algebra at a given time, and the average number of courses that the students were taking was five, the number of carrels needed for that algebra course would be 100/5, or 20. If the 90% rule was applied, the number of carrels needed would be 18. Further insight into the feasibility of this procedure might be gained by additional simulation.

(5) Implications of the Results for Characteristics of Graduating Students

If the autonomous scheduling procedures that were simulated were implemented, it could affect the motivation and maturity of students. These procedures could cause students to take more initiative and responsibility for their learning.

D

APPENDIX D

SYSTEM ANALYSIS AND COMPUTER SIMULATION OF THE 10TH-GRADE SOCIAL STUDIES AT NOVA HIGH SCHOOL

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Appendix D

A. INTRODUCTION

This chapter describes the application of system analysis and computer simulation to the study of the Nova High School in Fort Lauderdale, Florida.

Nova High School is part of a complex containing kindergarten through grade 12 that is planned for Broward County. Students from grades 7 through 12 attend the high school. The school, which is experimental, selects applicants from the total county. It operates on a trimester plan with a total of 220 school days per year. Classes are organized in a 70-minute class period; most classes meet four times a week.

The school plant is outstanding in terms of available resources and modern design. The buildings are organized on a departmentalized basis. There are four primary academic buildings: language arts, mathematics and social studies, science, and technical and special studies. In addition, there is an administrative building, a gymnasium, and two modern lecture halls.

The academic buildings are unique. Flexible classroom spaces surround a central learning resource area that contains carrels for individual study, spaces for small group conferences, a typing room, and lounge chairs. Some carrels are equipped with earphones and a dial system that allows students to dial for individual tapes. Other carrels are equipped with small television monitors. In addition, each classroom contains a television monitor and an overhead projector. The television studio is equipped for Closed-Circuit Television (CCTV) and Educational Television (ETV).

The primary goal at Nova High School is to evolve a high-quality educational system by using the best of the most modern resources and methods. There are no fixed procedures that define the plan. At the time of the analysis, certain emphases were apparent.

Work is being done in almost every department to develop a new curriculum for Nova High School. The level of training of the academic staff is unusually high. For example, the head of the Social Studies Department has a Doctor of Philosophy degree in Education.

Departments are organized into teams, and most of the teaching is done by teams. The school is attempting to develop an ungraded plan in which students are free to progress according to their ability. Some departments are actively engaged in developing plans and materials for operating their courses on a continuous progress basis. In addition to the emphasis upon individual progress of students, much large group instruction is encouraged at Nova High School. The excellent media for large group instruction

Appendix D (cont)

(including lecture halls and large classrooms) plus a student body that is increasing in size with an accompanying increase in the student/teacher ratio all tend to encourage large group work.

The 10th-grade social studies course was selected as the subject for the system analysis. This course, like any at Nova High School has been constantly changing. In 1963-64 the course was organized for continuous progress. In 1964-65 (the year that this study was conducted) the course was organized on a lockstep basis combining large group instruction, small group work, and independent study. During the 1964-65 year, one member of the Social Studies Department was spending all his time in developing materials so that the course could be placed back on a continuous progress basis in 1965-66.

B. PROBLEM

The study of the 10th-grade social studies course was focused on three problems.

The first two problems involved the use of the computer simulation capability described in Appendix B. The study was begun by first describing the course as a system and then by building a computer model of the course.

One reason for using simulation procedures was to explore if the procedures required to construct a computer simulation model would lead to insights and hypotheses about the course that otherwise would not emerge. It was reasoned that the detailed study and logical analysis required to formulate the steps for simulation, the detailed analysis required to program the model and cycle it on the computer, and the analysis of the output data would provide a much more detailed understanding of the operation of the course than could be gained by merely collecting data about the course. A second reason for simulating the course was to test the simulation procedures themselves. One test of the simulation procedures was to determine if they could be used to construct a model of a course which, for the most part, was group oriented. The work prior to this study had been focused on modeling continuous progress plan procedures.

A second test of the simulation capability was to determine whether the procedures for distributing activities within the model would generate output data that corresponded to the actual course distributions that were used to define the simulation model. In other words, this second problem was concerned with the question, "Would the simulation procedures produce valid data?"

Appendix D (cont)

The third major problem in the study of the social studies course was to determine if the procedures of system analysis and computer simulation could be used to identify problems and possible solutions relating to the following five objectives of the project:

- the roles of personnel
- the use of media
- the information processing procedures
- the use of space
- the characteristics of the graduating students

C. METHODS

1. System Description of Course

The first step in the procedure was to describe the social studies course as an operating system (Reference 8). In this step the data collected was used to develop flow diagrams that described the relationship among activities in the course. This analysis showed that the course was organized into 10 units, each of which lasted an average of about four weeks. Each unit was introduced by a lecture and ended by a unit test. On days other than the first or last day of the unit, the sections could start work in the class in any of five activities--teacher lectures, nonhuman-mediated presentation (film, TV program, or filmstrip), small group work, independent study, or taking a quiz. The probabilities associated with each activity were as follows: lecture--.375, nonhuman-mediated presentation--.125, small group work--.205, independent study--.235, and testing--.06. After any one of the above activities, the sections could continue with or be assigned to small group work or independent study. (At this point the probability of doing small group work was .50 and the probability for independent study was .50.) If students went into small group work, the time was divided between three activities: group research projects, discussions, and academic games. The probabilities for each of these occurrence activities were .437, .437, and .125, respectively.

2. Simulation of Course

The logic for developing a computer simulation model of the course was formulated on the basis of the system description. The computer simulation

Appendix D (cont)

model was developed using the procedures described in Appendix B, "Computer Simulation Capability."

The computer model included four sections of students going through a year's work in the social studies course. The activities for each section were determined in accordance with the probabilities defined in the system description. At each choice point or branch in the model at which the next activity was defined, a random-number generator-program was used to determine which branch or which activity the sections would be simulated as taking. A recording was made of the history of each section in the simulation. The recording contained the activities that the sections went through, the sequence in which the sections went through the activities, and the amount of time the sections spent in each of the activities. Summary data descriptive of the frequencies of activities for each section were printed out by the computer.

D. RESULTS

1. Comparison of Simulated Data and Descriptive Data

Table I shows the results of the simulation. The activities that were simulated are shown in the first column. The second column shows the estimated proportions of time for activities based on the descriptive data. The third, fifth, seventh, and ninth columns show the number of times that each activity occurred in the simulation for sections one, two, three, and four, respectively. The fourth, sixth, eighth, and tenth columns shows the proportion of the total class time devoted to each of the activities. The total number of class days, the total number of class hours, and the number of class days missed because of holidays and special school activities are shown on the three rows at the bottom of the table.

The proportions of time for activities were based upon the amount of class time that was devoted to the activity rather than the number of times that the activity occurred. The proportion was derived by the formula: $\frac{\text{activity x time}}{\text{total time}}$. For example, for section one, there were 71 simulated course lectures during the year. Each lecture lasted (on the average) 3/8 of an hour. Thus of the total 186 hours spent in class, 26.67 hours (equivalent to 14.4%) were devoted to lectures.

Examination of the proportions in Table I indicates that the procedures used in simulating the course tend to produce a set of simulated data that corresponds closely with the data that represent the actual course. These data suggest that the computer program logic is correct and that the random-number

Appendix D (cont)

Table I. Results of the Simulation Run

Activities (Column 1)	Estimated Proportions of Total Class Time Based on Descriptive Data (Column 2)	Number of Activities Section 1 (Column 3)	Proportions for Simulated Section 1 (Column 4)	Number of Activities Section 2 (Column 5)	Proportions for Simulated Section 2 (Column 6)	Number of Activities Section 3 (Column 7)	Proportions for Simulated Section 3 (Column 8)	Number of Activities Section 4 (Column 9)	Proportions for Simulated Section 4 (Column 10)
Lectures Large Group	14%	71	14.4%	65	13.7%	56	11.8%	67	14.9%
Media Presentation to Large Group	3%	21	2.8%	22	3.1%	19	2.7%	19	2.8%
Small Group Work	25%	73	20.6%	73	23%	76	21.9%	72	20.4%
Independent Study	29%	82	29.7%	78	26.6%	75	30.6%	71	28.7%
Unit Tests) Quizzes)	6%	10 7	4.0% 1.0%	10 10	5.6% 1.4%	10 10	5.6% 1.4%	10 6	4.4% .9%
Attendance & Assignment	7%	165	11.0%	158	11%	158	11%	150	8.9%
End of Class	7%	165	11.0%	158	11%	158	11%	150	8.9%
Miscellaneous Lost Time	9%		5.4%		4.6%		4%		10.1%
Total %	100%		100%		100%		100%		100%
Total Days Class			165		158		158		150
Total Class Hours			186		178		178		169
Days Missed			11		18		18		26

Appendix D (cont)

generator-program operates without bias. The fact that the data for all four simulated sections is very similar increases confidence in the reliability of the simulation procedures.

2. Analysis of Social Studies Course

The data from the descriptive analysis and the simulated data were studied to identify problems and possible solutions. This study focused on the five objectives of the total project: roles of personnel; effects of media; information processing uses; use of space; and effects of innovation on characteristics of graduating students.

E. IMPLICATIONS OF THE RESULTS

1. The Roles of Personnel

The most pressing problem at Nova High School is the teacher/student ratio of about 1/50. The many advantages of the school have attracted an increased number of applicants, and the school must take as many students as it can because it serves the entire county rather than a district of the county. It should be immediately apparent that teachers have little time to spend with individual students. The poor teacher/student ratio tends to restrict the alternative instructional plans that can be used. Teachers either work with the group as a whole, or require that students work independently a large portion of the time. Forty-six percent of the student's time is spent in a group listening to a lecture, listening to a mediated presentation or in independent study. If the other activities requiring large groups---testing, attendance accounting, and making assignments--is added, 66% of the class time is devoted to large group and independent study. The capacity of the teachers to work with small groups is limited by the poor teacher/student ratio. When the number of small groups within a section is limited to four or less, the small group size (16-25) is still larger than is generally considered desirable for effective small group work. Two teachers with a section that divides into four small groups can spare only one-half of their time with each group.

If it is assumed that approximately 53 hours of class time during the course are spent in independent study, that the average class size is 71, and that two teachers are working with the class, the teachers could spend 90 minutes a year with each student. At this rate a teacher could spend only an average of 9 minutes with each student on each unit of the course. True, not all students need an equal amount of time with the teacher, but the limited resource for individual consultation with students would mean that if

Appendix D (cont)

teachers increase the time they spend with very many students to exceed the average, they will exclude some students from any individual consultation.

There are a number of possible solutions to this problem. By far the best solution would be to increase the teacher/student ratio by either decreasing the size of the student body or by increasing the size of the staff.

Another solution is to make greater use of paraprofessionals and students. Steps in both of these directions have been taken in the course. The students have been instructed in small group procedures in hope that they could take major responsibility for the small group work. In addition, teacher aides have been used to help with test-scoring.

Teachers should develop procedures for identifying students and paraprofessionals with competencies that can be used in the course. Having such a resource will make it possible to have smaller groups and enable the teacher to concentrate on individuals who need help.

An additional solution which is under consideration at Nova High School is to restrict the teaching responsibilities of teachers so that they can use their time more effectively. This plan proposes to make teacher(s) responsible for individual units of information in the total social studies curriculum rather than parts of single courses. Thus a teacher might specialize in political units throughout all of the social studies courses. In this way the teachers can devote their energies to becoming expert in a more restricted range of the curriculum content. This should improve the quality of instruction and also should provide more teacher time for work with students.

Another solution to the problem is to improve testing and information processing procedures so that students who are in need of help and students who are capable of helping can be identified.

The major difficulty with most of these solutions is that they require the time of the teaching staff for development, and the staff is normally too busy to provide the time.

2. Use of Media

A greater use of the media available would enable more teachers to have more time with the students. Approximately 17% of the class time is devoted to lecture presentation by the teachers. Only about 3% of the class time is used for presentations that are mediated by nonhuman means. When the excellent facilities at Nova High School are considered, it is surprising

Appendix D (cont)

that there is so little use of media. If teachers made more use of the facilities that are available, teacher lectures could be recorded and reproduced so that the teachers themselves would need to devote considerably less time to large group presentation. When the hours required for preparing a group lecture plus the actual lecture time are taken into consideration, the amount of teacher time gained could be considerable. Approximately 27 hours of class time were devoted to lecture presentation during the course. If the formula is used that two hours of preparation are required for every hour of presentation, the amount of time that might be gained by automating the lecture function could be as high as 81 hours of teacher time. This time could then be added to the average amount of time currently used in individual consultation, and would amount to an additional 68 minutes that could be devoted to each student a year.

Although the time saved in preparing presentations would not be applicable during the scheduled course time, more flexible procedures for scheduling activities would allow the students to meet with the teachers outside of regular course hours for consultation.

If lectures were automated, individual students could consult with the teacher during the presentations because the materials would be available for later individual viewing.

When the possible advantages of automating the lectures (at least to a greater degree) are considered, the question is raised, "Why haven't the resources at Nova High School been used to automate the lectures?"

Nova High School personnel in the social studies course have been seriously concerned with this problem, and steps are being taken to make progress in this direction. When the course was first started on a continuous progress basis, teacher lectures were recorded on audio tape and were made available at the individual carrels in the learning resource center for call-up through the Chester Dialog System. However, the teachers in the course were concerned with the degradation of the instruction that could result from not having visual aids to accompany the lectures. The teachers at Nova High School usually use overhead projectors during lectures.

The teachers have considered the possibility of making video tapes of their lectures. Facilities are available at Nova High School for making a video tape of the lectures and for making the tapes available for group presentation via the CCTV system or for individual viewing at the TV monitors in the learning resource center carrels. However, the cost of one video tape is $60. If tapes were made for each of the 71 lectures and the tapes were stored for use the next year--the capital invested could be as high as (71 x $60) or $4,260.

Appendix D (cont)

A second problem associated with producing the lecture for video tape recording is that the visual materials have to be specially prepared so that they can be picked up by the TV camera.

A third reason for not expending a large amount of money to produce a library of tapes for lectures is that the social studies teaching staff is in the process of developing a new curriculum for social studies at Nova High School. One teacher, in fact, is working full-time on preparing materials for a continuous progress course in social studies. The school plans to implement this course next year. The staff hesitates to build a library of materials before they have had a chance to try out and evaluate the materials with students. However, it is planned that audio tapes will be made of the lectures next year so that the tapes will be available for individual students who may have missed the lectures.

The analysis suggests that the media could be used to a much greater degree at Nova High School. Teachers need to give serious consideration to the relative advantages of large group lecture versus individual consultation with the students.

One other problem regarding the use of media at Nova High School must be considered. If the school is successful in moving more in the direction of a continuous progress plan, television as a media resource may be insufficient for meeting the demand. Studies of students allowed to progress at their own rates in a continuous progress plan show that as time goes along the students become more and more heterogeneous as far as their work on the courses is concerned. In time, few students would be working at the same point in the curriculum. Almost all students who wish to view TV presentations individually will want to view a different subject on tape. At any given time there could be as many different requests in one course as there are students. Obviously, a system that is capable of providing only five or six different presentations at one time cannot meet the demand. A system that may eventually be less expensive and more appropriate to this kind of development would be to use 8-mm sound-motion picture cartridges in individual viewing devices.

The amount of time devoted to lecture, plus the shortage of teacher time for individual contact during the large amount of time spent in independent study, tends to create a learning environment that is not highly responsive to individual differences in ability and interests of the learners. One solution that can increase the responsiveness of the system to individual differences is to develop more advanced information processing procedures.

3. Information Processing Procedures

Information processing procedures could be developed so that teachers are more aware of their students' needs. In this way they could plan their time so that they could spend the limited time they do have where it is most needed. Such procedures would require more frequent testing, computer diagnosis of test data to expedite definition of learning problems, and identification of those people who need help most badly. An information-processing procedure with these capabilities has been described by the authors (Reference 20). This description details the procedures that might be used to track student performance and to identify students in need of help. The emphasis in this system is upon providing a teacher with more information so that he can manage use of his time and instructional activities more effectively. The system, by making more and more timely information available on student performance enables teachers to treat the students on more of an individual basis. In the social studies course the individual teachers cannot keep track of each student's performance, problems, and interest. By contrast, a computer can collect and store this information and can make it available to a teacher when he is ready for it in a form that helps him make decisions in the interest of the individual students. Certainly, as the course is moved back in the direction of the continuous progress plan, the information processing procedures alluded to above would be essential.

If the teachers divide up the course so that each teacher on the social studies staff becomes responsible for specific units of work, the need for an information management system should be much greater. The teachers will not have the students for the whole course; thus they will have less opportunity to know the students. The computer, by collecting, storing, and presenting information about the students, would help to overcome this problem. The teachers could get a history of each student from the computer. The history, in addition to grades and test scores, could contain comments made by one teacher that would be helpful to others. These comments could include such things as the perceptions that teachers have of the student as an individual and perceptions that the student has of himself.

The plan to operate the course under a continuous progress plan indicates that the space required for large group instruction may not be adequate or appropriate for the greater emphasis upon independent study that is inherent in a continuous progress plan.

4. The Arrangement of Spatial Resources

The number of carrels for individual study in the learning resource center is far too small to permit all of the students to use these spaces simultaneously. The carrels were designed for a plan where a limited number of students would want to use the area at any given time. If the school moves away from a heavy reliance on large group instruction to a more individualized plan, the resources

Appendix D (cont)

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3. Information Processing Procedures

Information processing procedures could be developed so that teachers are more aware of their students' needs. In this way they could plan their time so that they could spend the limited time they do have where it is most needed. Such procedures would require more frequent testing, computer diagnosis of test data to expedite definition of learning problems, and identification of those people who need help most badly. An information-processing procedure with these capabilities has been described by the authors (Reference 20). This description details the procedures that might be used to track student performance and to identify students in need of help. The emphasis in this system is upon providing a teacher with more information so that he can manage use of his time and instructional activities more effectively. The system, by making more and more timely information available on student performance enables teachers to treat the students on more of an individual basis. In the social studies course the individual teachers cannot keep track of each student's performance, problems, and interest. By contrast, a computer can collect and store this information and can make it available to a teacher when he is ready for it in a form that helps him make decisions in the interest of the individual students. Certainly, as the course is moved back in the direction of the continuous progress plan, the information processing procedures alluded to above would be essential.

If the teachers divide up the course so that each teacher on the social studies staff becomes responsible for specific units of work, the need for an information management system should be much greater. The teachers will not have the students for the whole course; thus they will have less opportunity to know the students. The computer, by collecting, storing, and presenting information about the students, would help to overcome this problem. The teachers could get a history of each student from the computer. The history, in addition to grades and test scores, could contain comments made by one teacher that would be helpful to others. These comments could include such things as the perceptions that teachers have of the student as an individual and perceptions that the student has of himself.

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4. The Arrangement of Spatial Resources

The number of carrels for individual study in the learning resource center is far too small to permit all of the students to use these spaces simultaneously. The carrels were designed for a plan where a limited number of students would want to use the area at any given time. If the school moves away from a heavy reliance on large group instruction to a more individualized plan, the resources

Appendix D (cont)

for independent study will be grossly inadequate. Some evidence that a lack is already being felt is reflected in the fact that students doing research as a group project must send a representative of the group to the learning resource area rather than go as individuals.

The small number of carrels also necessitates that students do their individual work in social studies at their classroom seats. These seats are adequate for listening to lectures and for taking notes, but they may not be appropriate for independent study. If the school does succeed in moving more and more in the direction of the continuous progress plan, consideration should be given to acquiring a larger number of carrels for independent study. A plan that might allow for both better use of the resources at Nova High School and for more individualized instruction is the autonomous scheduling procedure described in Appendix C and Reference 15. This plan calls for breaking away entirely from the lockstep system. Under this plan, students are not assigned to classes for specific times, but are free to work independently a large portion of the day and are responsible for their own budgeting of time. The use of an advanced instructional management information system would enable students to schedule meetings with both teachers and groups when they need them or are ready for them. It is recommended that Nova High School personnel be trained in the use of the computer simulation capability and that they use this tool to help them develop plans for better use of their resources.

5. Effects on the Characteristics of Students

It is difficult to define problems and trends in this area. If Nova High School continues to use the large group procedures that they are using in 10th-grade social studies, then students will progress in a lockstep fashion and will all tend to graduate in a defined and predictable number of years. Heterogeneity of performance within a course will tend to be very great for the following reasons: It will not be possible to arrange resources in such a way that the system responds well to the individual differences of the learners. The students with ability for better achievement who can work independently with little help will continue to do well, but the students with less ability will probably get only limited help, and will continue to do poorly. The major variable that will affect performance will be the procedures used to select students rather than the procedures of instruction.

If the whole school moves in the direction of the continuous progress plan, the students can be treated on more of an individual basis. By focusing on the individual needs of students the instruction would tend to have more of an impact and the average performance of all students would be raised. Most noticeable of all, however, the rates of progress and the time of graduation would vary markedly. The effects of variations could be studied by Nova High School personnel with the simulation capability that was developed for the project.

APPENDIX E

SYSTEM ANALYSIS AND COMPUTER SIMULATION OF A BIOLOGY COURSE AT THEODORE HIGH SCHOOL

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Appendix E

A. INTRODUCTION

Theodore High School (Reference 1) is located in Theodore, Alabama. The community is a suburb of Mobile and the high school is part of the larger city's school system. Theodore High School is a six-year combined junior-senior high school staffed by a principal, an assistant principal, a coordinator of instruction, a coordinator of guidance, and 50 instructors.

The staff at Theodore became active in making changes to instruction during the 1958-59 school year. Inspiration for their early effort came from publications issued by the National Association of Secondary School Principals Commission on the Experimental Studies of the Staff in Secondary Schools. By late 1960, the staff at Theodore High School had identified its major objective as the individualization of instruction and had prepared a master plan for extending the concept to all instruction in the school. During the next five years (1960-1965), about $80,000 was spent implementing the plan. The money was used to pay the salary of the coordinator of instruction, to hire teachers during the summer months for preparing instructional materials, and to publish the new instructional material.

As a consequence of its curriculum improvement program, Theodore High School has individualized the majority of its courses and is striving toward its goal of extending the concept as far as is practically possible. In the typical course at Theodore High School students work on their own, using study guides or programmed instruction materials. Instructors are present in the student work area to give individual assistance to those who encounter problems in understanding the course content. Instructors neither lecture nor make group presentations. Typically, courses are subdivided into units of study that culminate in a test. A unit test is used to determine whether or not a given student has attained mastery of the unit.

B. PURPOSES FOR THE STUDY

The present study has two purposes. The first purpose is to apply system analysis and computer simulation procedures to the study of an exemplary individualized course at Theodore High School in order to identify organizational problems and suggest possible solutions. The second purpose is to produce information from which implications can be drawn relative to the objectives of the project, New Solutions for Implementing Instructional Media Through Analysis and Simulation of School Organization. These objectives are to:

Appendix E (cont)

- define new roles for school personnel;
- provide information on the effects of new media on student interactions;
- describe new applications for data processing;
- provide information on amount and arrangement of space in innovating schools; and
- provide estimates of the characteristics of students graduating from innovating schools.

C. PROCEDURES FOR SIMULATING THE BIOLOGY COURSE

The biology course at Theodore High School was selected by school officials as exemplifying their approach to individualized instruction. Project personnel visited the school several times and collected data in order to describe this course (Reference 2). These data were then used to define the course as a system for processing students through the 10 units of study that comprise the course (Reference 6). In this system the course is conceived as a sequence of 10 activities (analogous to the 10 units) through which students progress according to specific rules that govern their progress.

The specification of the rules governing the progress of students and the definition of the activities to represent the course served as primary data for simulating the operation of the biology course on a computer. The general procedures for constructing the simulation models are described in Appendix B. The specific procedures for the Theodore High School study involved simulating the progress of 100 students through the computer model that was constructed to represent the biology course. The simulation was continued for a time to represent the 175 days of the course and a recording of how much "time" each simulated student spent in each activity was produced.

In the actual biology course, students receive direction from a study guide, elect the specific tasks within a unit they will work on, and schedule themselves for these tasks. As a consequence, at any given moment in the course many different tasks are being performed by many different students. Students will vary with respect to how many tasks and how many units they have completed. However, students are not free to take as much time as they want in order to complete the 10 units in the course. They are constrained by formal progress goals that apply equally to everyone in the course. These goals are published in the study guide and require that the sequence through Unit 2 be completed by the end of the first quarter; through Unit 5 by the end of the semester; through Unit 8 by the end of the third quarter; and through Unit 10 by the end of the course.

Appendix E (cont)

In defining the biology course for simulation, the effects of group progress goals were taken into account in formulating a rule to govern the progress of students. This rule is discussed in Section E below.

D. RESULTS OF SIMULATING THE BIOLOGY COURSE

The average amount of time spent by all students in each of the 10 units that comprise the biology course provides an indication of the relative importance of each unit from an overall viewpoint.

A content analysis of the study guide identifying the kinds of tasks and their frequency of occurrence in each of the 10 units expresses the course designer's view of the importance of each unit. By arbitrarily assigning time values to these tasks on an assumption that all of them will be completed in 175 days, it is possible to show the relative importance of each unit as implied by the course designer. These data appear in Table I in the column labeled "Study Guide." Unit 3 contains the largest number of tasks and is viewed as requiring 21 days for its completion. Units 2, 7, 9, and 10 require 16 days each; the other units require times in the range in between these extremes.

The average amount of time actually spent in each unit by the 156 students who were enrolled in the biology course is shown in Table I in the column labeled "Actual." These times range from a low of 7.2 days on Unit 10 to a high of 26.3 days on Unit 9, with the other units having values between these two extremes. The column labeled "Simulation" shows comparable data generated by simulation. The simulated data are similar in value and patterning to the actual course data. By contrast, the study guide data are quite different from both the actual and the simulated data.

Table II shows the extent of progress of all students (column labeled "Actual") at the end of the actual biology course. One hundred percent of the students completed the first unit, 95% completed Unit 2, 92% completed Unit 3, etc. Of a total of 156 students who were enrolled in the biology course during the year, 54% completed Unit 10.

The column labeled "Simulated" in Table II shows comparable data produced by simulation. A comparison of the simulated data with the actual data shows that the results from the course were either closely approximated or reproduced through simulation. For example, 54% of the simulated students completed all units of the course. This result agrees exactly with what occurred in the actual course.

Appendix E (cont)

Table I. Average Number of Days Spent by All Students in Each Unit

Unit	Study Guide	Average Days in Unit	
		Actual	Simulation
1	19	25.5	24.4
2	16	17.5	19.2
3	21	21.0	21.0
4	17	18.0	16.6
5	19	12.4	13.0
6	18	21.5	23.4
7	16	10.6	10.4
8	17	14.7	15.8
9	16	26.3	25.9
10	16	07.2	09.9

Appendix E (cont)

Table II. Extent of Progress of All Students Enrolled at End of Biology Course (175th Day)

Unit Completed	% of Students	
	Actual	Simulated
1	100	100
2	95	100
3	92	100
4	89	98
5	83	90
6	79	88
7	77	78
8	75	77
9	72	73
10	54	54

Appendix E (cont)

E. DISCUSSION OF BIOLOGY COURSE SIMULATION

The rule used in simulation to control the progress of students through the course is discussed here because of its implications for the design of the biology course. The rule may be summarized as follows: the amount of time a specific student spends in accomplishing the work in a unit of study is determined by the number of days he has spent in the course. By using this general rule for simulating the biology course, the simulated data on the average amount of time students spent in each unit and the overall student progress described in the results section were produced. The great similarity between these simulated data and data obtained from course records is a strong argument for believing that this rule actually governed student behavior during the course.

The lack of similarity between the average time students spent in each of the 10 units of study and the allocation of times implied by the course study guide was also noted in the results section. This dissimilarity shows that course content does not explain the variation in time spent in the units, and lends credence to the belief that the relative importance of the units (as defined by the average time that students spend in them) was determined by the students on the basis of group progress goals. Additional support for this belief comes from an examination of individual student records. This examination showed many instances of student behavior where they appeared to be pacing themselves relative to course deadlines. For example, one student started the second semester by spending 50 days in Unit 6 and 24 days in Unit 7. He then completed Units 8, 9, and 10 in a total of 11 days.

From a course designer's viewpoint, the use of common progress goals for all students in a course is attractive for two reasons. One reason is related to the administrative task of keeping track of the progress of each student. The use of a single progress standard (e.g., all students will complete a specified amount of work by a certain date) makes it simple to evaluate each student in terms of his success in meeting the standard. The alternative of establishing individual progress goals and of assessing the success of a student relative to his unique goals is a formidable task from an administrative viewpoint.

A second reason for using common progress goals rests on a belief that common goals have a desirable effect on the amount of work students will accomplish. Data from the course show that, in general, students respond by spending relatively less time on units that precede deadlines.* However, the date

*See the column labeled "Actual" in Table I. Units 2, 5, 8, and 10 precede deadlines; Units 3, 6, and 9 follow deadlines.

Appendix E (cont)

also show that students spend relatively more time on units that follow deadlines. Apparently group progress goals do influence students to meet deadlines but do not influence them to continue to work consistently at their top capability for progress.

The content analysis of the biology course study guide indicated that the 10 units should each require roughly similar amounts of effort on the part of students (from 16 to 23 days, as is shown in the column labeled "Study Guide" in Table I). In considering the actual performance of students in the course (from approximately 7 to 26 days--see the column labeled "Actual" in Table I), it is of interest to speculate as to how it is possible for students to vary so greatly from the expected times. One hypothesis is that the course is "too easy" for some of the students. These individuals tend to "mark time" by getting more deeply involved in units that follow deadlines, feeling secure that they can adjust their pace to the demands of the course when it becomes necessary. Data bearing on this hypothesis was obtained by a second simulation study performed in connection with the biology course at Theodore High School, described below.

F. PROCEDURES FOR SIMULATING THE EXPERIMENTAL COURSE

Project personnel formulated an experimental version of the biology course. This version attempted to represent the lifting of the requirement that all students accomplish the same amount of progress by certain dates. To achieve this, the simulated course was altered in relation to the regular version so that a specific student's progress was governed by an individual progress rate. An individual progress rate for each student was determined from his actual performance in Unit 3 in the biology course. Unit 3 was selected as a standard because the average amount of time spent in that unit by all students was the same as the amount of time allocated to it by the study guide (compare the "Study Guide" column with the "Actual" column in Table I). It was reasoned that the student progress distribution that produced this average would be related to course content and would be the least affected by course deadlines.

The initial progress rate assigned to each student was subject to two alterations during the simulation of the course. One change was made for all students alike. This change altered the initial rate to conform to the relative length of each unit as compared with Unit 3. The second adjustment made to an individual's progress rate was based on the assumption that a given student would not be entirely consistent in his performance as he progressed from one unit to the next. The specific rule used for his adjustment was to assign the student to the same rate that he achieved in a prior unit 90% of the time, to a lower rate 5% of the time, and to a faster rate 5% of the time.

Appendix E (cont)

One hundred students were simulated as working in this experimental course. All began work in Unit 1 on the first day of the course and were processed for 270 days. The simulation was carried beyond the 175 days that comprised the actual biology course in order to simulate the effects of a longer course.

G. RESULTS OF SIMULATING THE EXPERIMENTAL COURSE

The rate of a student's progress can be expressed by the time needed to complete all 10 units. In simulating the experimental course, it was found that some students would complete the course as early as the 15th week, and that by the 54th week (270th day) 82% of the students would finish the course. Table III shows the overall progress of the 100 simulated students in the experimental course in terms of the percentage of students completing the course by week. The cumulative percentage of completions at the 35th week (comparable to the time for completion of the actual biology course) is of special interest. While 54% of the students completed the actual biology course, only 38% of the simulated students completed the simulated course in a comparable time period.

H. DISCUSSION OF THE SIMULATED EXPERIMENTAL COURSE

Approximately one-third of the simulated students in the experimental course finished before the 35th week. This datum suggests the possibility that many high-ability students may have been "marking time" in the actual course and supports the hypothesis that this may have contributed to the discrepancy between the time spent in a unit and the time allocated to it by the study guide.

It is interesting to compare the efficiency of the actual 35-week biology course with the 54-week experimental course. In terms of overall performance, 54% of the actual students finished the biology course as compared with 82% who finished the longer experimental course. By permitting high-ability students to finish the experimental course early, 425 student-weeks of instruction are saved as compared to a course that would require every student to attend for 35 weeks. The "cost" to instruct the students who continued beyond the 35th week in the experimental course was 332 student-weeks of time as compared to a 35-week course. By contrast, the "long" experimental course enabled 82% of the students to finish as compared to 54% who finished the actual biology course. The long course would have saved 93 weeks of student effort.

Appendix E (cont)

Table III. Progress of Students in the Simulated Experimental Course by Week

Week	% of Students Completing Course	Cumulative %	Week	% of Students Completing Course	Cumulative %
15	01	01	36	01	39
16	--	01	37	03	42
17	--	01	38	02	44
18	--	01	39	07	51
19	02	03	40	11	62
20	02	05	41	04	66
21	08	13	42	05	71
22	01	14	43	--	71
23	03	17	44	02	73
24	01	18	45	01	74
25	--	18	46	02	76
26	01	19	47	01	77
27	02	21	48	--	77
28	01	22	49	01	78
29	01	23	50	--	78
30	03	26	51	--	78
31	04	30	52	01	79
32	02	32	53	02	81
33	01	33	54	01	82
34	02	35			
35	03	38			

Appendix E (cont)

Four weeks (the 39th through the 42nd weeks of the experimental course) were highly productive in the sense that approximately one-third of the simulated students who finished the experimental course completed it during this period. This indicated that if progress in the actual biology course were to be based on course content and student ability, the 35-week normal school year is not an optimal period of time to conduct the course. By extending it a mere seven weeks, its efficiency could be increased by more than 30%.

I. IMPLICATIONS OF THE STUDY FOR PROJECT OBJECTIVES

The biology course at Theodore High School is sufficiently innovative in its individualized aspect to have many implications for the objectives of this project. This section summarizes what has been learned.

1. New Roles for Personnel

As contrasted with conventional classrooms, the organization of the biology course places new demands on both students and other school personnel. In individualized courses, students have a major responsibility for their own education in the sense that they must make many decisions. Using the study guide to get information about the objectives for a unit and the activities that must be accomplished in order to complete the unit, the student must decide what he will do on a given day and then must schedule himself for many of these activities. For example, he may have a choice whether he will study his text, work in the laboratory, or go to the library to prepare a research paper. For laboratory work, he is required to plan ahead and to schedule his work in the laboratory prior to the day he wishes to work; the same scheduling requirement is made for discussion groups and tests. This requirement to do advanced planning is necessary from the instructor's viewpoint, so that he may anticipate the needs of students for space, materials, etc.

The student's responsibility for decision making has an even larger dimension when the total school is concerned. Procedures exist so that a student can schedule himself on a day-to-day basis to be away from his regular biology period and to attend another subject if he can justify his need to the instructor. The same is true in the other direction, that is, a student can spend additional time in biology at the expense of another subject. Moreover, although assigned to a regular period in biology, he can arrange to attend additional sessions of the course during the other periods it is given, with prior approval.

Appendix E (cont)

During the current year (1965-66) Theodore High School has made a procedure available to about 50 of its students whereby they can arrange their daily schedule to suit their own needs without prior permission. If a student needs to work for two or three periods in one subject on a particular day, he is allowed to make the decision and to do so merely by not attending his other classes. He is expected to "pay back this time" to the courses he misses at a later, more appropriate time, so that, in general, each subject gets its fair share of his time. School officials report that this procedure is working well and that they intend to extend the privilege to more students with the eventual goal of including all "responsible" students.

The use of group progress goals in connection with this procedure may make it difficult for students to balance the amount of time spent on each of their subjects. It is entirely possible that students may mark time in a class, as apparently happens in the biology course, merely to satisfy the requirement of equal time for each course. The suggested solution is to use individual progress goals as was assumed for the simulated experimental course described above. With this procedure, a student's time would apply to his own goals and he would not be constrained by the group.

The instructor's roles in the biology course differ from the roles in a conventional course with regard to two functions. The first of these is related to his role as a course designer; the second pertains to his responsibility for monitoring and controlling the progress of his students. At Theodore High School, most instructors have designed their courses through the medium of a study guide and associated mastery tests. This is done so that the instruction can be individualized, that is, so that a student can learn the content of a course on his own. The specific skills and techniques for designing courses are not well defined, consequently courses and units within courses vary considerably. The variation in the average amount of time spent on the 10 units in the biology course is an example (see Table I).

Project personnel believe that there is a technology available for designing courses. Briefly, this involves first analyzing the substantive content to be presented in terms of the observable behavioral changes in students that the course intends to accomplish and then devising assessment devices to determine whether or not the changes occur. The practical problem, however, is caused, not by the lack of technology, but rather by the lack of personnel resources within the school to use the techniques. The present biology course design required about three man-months to produce. Modifying this course to the more exacting specifications implied here could very well require two man-years. The prospect of providing well-designed courses for secondary schools, in general, is very poor unless substantial support external to the schools is forthcoming.

Appendix E (cont)

The second function that shapes the roles of the biology instructors is that of monitoring and controlling the progress of the students in the course. The procedures used in performance of the monitoring aspect of instructional management in the present biology course include establishing minimal progress requirements for the course; checking of products produced by students (papers, research reports, quizzes, etc.); recording of the activities completed; administering mastery tests; and assigning unit "grades" relative to the group progress goals. The controlling aspect of instructional management includes most of the instructors' interaction with students as a result of the data collected through monitoring. This may include explaining content material or requiring a student to do additional remedial work.

The tasks involved in instructional management in the experimental course are no different from what they are in the actual biology course, but the size of the job would be substantially increased because of the use of individual progress goals and the need to monitor student progress with respect to them. This task, discussed in greater detail in Section 3, below, is best conceived in connection with an information processing system to provide personnel with useful information to help in the management of instruction.

2. The Use of Media

The media used for instruction in the biology course are primarily a study guide, a textbook, a laboratory manual, and assigned "outside" reading. The study guide directs students to the specific reading and laboratory work that is to be accomplished in connection with each unit in the course. Since the instructors do not present content through group lecture or demonstrations, the media used are of fundamental importance in the communication of substantive material to students.

Use of a study guide provides a course designer with optimum flexibility in choosing the other media he believes will meet his course objectives. The guide enables the designer to direct students to use multiple media for instruction. The biology course, for example, is able to incorporate several standard texts into the course in this way, although one particular text serves the course as a primary source of instruction. In addition, the course makes use of filmstrips, biological specimens, and small group discussions which are programmed into a predetermined place in the instructional sequence by the course designer. The selection of media should be completely dependent on the educational objectives of a course; therefore, selecting media is intrinsically a task in the technology of course design. In practice, however, the presence of media resources often predetermines the course objectives, as when a school has purchased a language laboratory or a closed-circuit television system.

Appendix E (cont)

Some educators are concerned that individualized instruction will rob students of the opportunities for student/student and student/teacher interactions that are afforded by conventional classrooms. On the contrary, this problem can be handled quite easily in an individualized course. Once a course designer recognizes interaction as an objective of his course, he can program as much group discussion or as many student/teacher consultations into the instructional sequence as he feels is necessary. This procedure ensures that each student is exposed to the same interaction experiences. By contrast, interaction in a typical conventional classroom is subject to the teacher's style and the personality characteristics of the students.

3. Uses of Data Processing

A problem for data processing in connection with the biology course has been identified in discussing the instructional management role of the instructor in Section 1, above. There is a strong likelihood that, in general, the problem of monitoring and controlling students with regard to their individual goals is a major deterrent to the development of individual progress courses. Solutions to this problem are available through applications of modern data processing technology.

Recently project personnel held a conference with Theodore High School officials. This meeting resulted in the formulation of some general requirements for an instructional management information system. These requirements are:

- The system will store a model of a course which is, in effect, the designer's version. This model includes all of the discrete activities provided in the course definition with a time value assigned to each activity. In concept, this model is similar to the column in Table I labeled "Study Guide," where the amount of time for each unit in the biology course, as derived from the content analysis of the study guide, is presented. The time values in the model are estimates provided by the designer as to how long each activity should take the average student.

- The system will store individual goals for each student related to this general model. Original estimates can be based on his aptitude, but these should be updated periodically in terms of his actual performance.

- The system will collect and store daily progress data from each student and compare these data with his individual goals.

Appendix E (cont)

- The system will generate displays providing information for instructors so that they can decide about allocating their time among their students.

It is quite feasible to implement a manual system for accomplishing the above requirements in the biology course. Such a system would probably require the full-time services of one clerk to collect data and maintain charts for display purposes. However, a computer-based system would be much more powerful and useful for this task, and could be used for all courses. In addition, a computer could be used for many other tasks in the school, such as attendance accounting, cost accounting, scheduling, etc.

4. Space

The biology course is conducted in an area where one instructor can easily supervise students whether they are studying, working in the laboratory, taking tests, or engaged in small group discussions. Testing, study, and discussion share a large classroom. The laboratory is in an adjacent room. The use of student assistants to aid in supervision enables the instructor to consult with students in his office which is connected to the laboratory.

The major problem with space is the sharing of the study and test space with group discussion. Testing and studying are compatible when sufficiently isolated because both are quiet activities. The present course at Theodore High School provides for isolation of students for both activities. Group discussion is not compatible with the other two activities however, and interference both ways results. The instructors are aware of this problem and propose to place a screen between the two areas.

The general procedure at Theodore High School of having students do their individual study and testing in large classrooms supervised by a teacher who can give assistance in the subject should be noted. School officials support this procedure in preference to the use of individual carrels. They believe that students in an open area are easier to supervise because they are visible.

5. Student Characteristics

The study of the biology course at Theodore High School has not provided specific information pertaining to the characteristics of high school graduates. The procedure of allowing students to make daily decisions concerning their activities in the course and of requiring them to take the responsibility for scheduling these activities may have subtle long-range

Appendix E (cont)

effects, however. Giving students this kind of experience at the secondary level may result in better preparation for all posthigh school activities.

The data from the simulated experimental course provides implications for graduates from the school of the future, where every course is organized on an individual progress basis. The data indicate, for example, that some students will finish a typical course such as biology in as little as one semester, while others will take more than three. If these data can be extrapolated to all courses, and if other conditions remain as they are, some students may finish a standard four-year high school education in two years while others may take more than six. Another important difference between the graduates of this hypothetical school and those of today's schools is that all students in the school of the future will have learned the same skills to the same level of proficiency when they finish a particular course, whether they take one semester or three to complete the work. If such is the case, a starting place for posthigh school education will be more precisely defined than it presently is.

While not directly related to the topic of student characteristics, this may be the place to indicate two other major problems whose solutions are assumed in the design of individual progress courses. The first is that students who finish a specific course will be able to go to work immediately in another course. This implies that all courses in a school must be organized for individual progress before the system can work well in any one course. There is a possibility, however, that a single department may be organized for individual progress while others in the school are kept on a group progress basis. Many schools, for example, operate their typing courses on an individual progress basis.

The second problem is much larger in scope and pertains to crediting students on national standards. The presently used standard, the Carnegie unit, is based on the number of hours a student spends in a classroom. Obviously this idea is directly opposed to a concept of credit based on individual achievement. In the simulated experimental course, the students who finished in 15 and the students who finished in 54 weeks both attained the same degree of mastery in biology, yet neither took a "standard" biology course as measured by classroom hours.

One alternative to standards based on time in the classroom is to base them on individual scores attained in national achievement tests. Both the lay public and the educational community share a concern on the advisability of using national tests to describe an individual's achievement. It may be a number of years before resistance to the idea diminishes to the point that students can be credited in this way.

APPENDIX F

SYSTEM ANALYSIS AND COMPUTER SIMULATION OF A

11TH-GRADE ENGLISH COURSE AT BUENA VISTA HIGH SCHOOL

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Appendix F

A. INTRODUCTION

Buena Vista High School, Saginaw, Michigan, is a four-year high school containing grades 9 through 12. The organizational structure is fairly conventional. Under the direction of a superintendent who is chief officer for the district, the high school is administered by a principal and an assistant. Other personnel associated with instruction include 29 teachers, two counselors, a librarian, and three television personnel. Eight interns from nearby Central Michigan University also participate in the instructional program.

The major innovation at Buena Vista High School is team teaching via closed-circuit television (CCTV). As a plan for organizing instruction, team teaching delineates and emphasizes several functions that go on in a regular classroom. These include large group presentations, small group discussions, and independent study. Advocates of team teaching believe that a typical classroom does not emphasize these functions by systematically organizing resources to support them. For example, a typical class includes 30 to 40 students and is too large for discussion. On the other hand, a class of this size is not nearly as large as it could be for a lecture or independent study. By pooling several typical classrooms where students are all taking the same subject, it is also possible to pool the teachers into "teams." A typical teaching team as it is organized at Buena Vista High School includes a team leader, a teacher, and an intern. The leader provides over-all leadership in planning, presenting, and evaluating the course. His normal salary is increased up to six percent, depending on the size of the class for which he is responsible. The second teacher and the intern work with the team leader and are responsible to him. Usually, the team leader presents the large group instruction. The staff at Buena Vista High School believes that the effectiveness of large group instruction is considerably heightened by the use of closed-circuit television. This medium for presenting course content is viewed as having the following advantages over live lectures:

- The teacher plans more intensively and is stimulated to optimum performance because of his greater visibility on television monitors in the staff room and school offices.

- The relative brevity and fixed length of a presentation forces the teacher to organize his talk more thoroughly, taking into account the essential points to be covered in a lesson. Rambling "free association" and unnecessary redundancies tend to be eliminated.

- The use of visual illustrative materials is encouraged and facilitated by television. The resources of the entire television broadcasting

Appendix F (cont)

industry, with its emphasis on visual impact and techniques of enlargement, superimposition of text, animation, etc., are made available to the school classroom.

- Television serves to emphasize the student's role as listener and watcher, and the teacher's role as presenter. Because they are not in the same room, the teacher and student cannot interfere with each other's roles.

The television system is used each hour of the day, every day, to present a telelesson (as it is called) at Buena Vista High School. Typically, a telelesson lasts about one-half of a school period. Some courses present telelessons twice a week on Tuesdays and Thursdays while others give telelessons three times a week, on Mondays, Wednesdays, and Fridays. After the telelesson, the teacher sometimes proceeds from the television studio to the classroom, and either he or the second teacher conducts a follow-up discussion to complete the balance of the period. Sometimes, the balance of the period consists of further lecturing in the classroom using visual aids via an overhead projector. One reason the teachers sometimes continue the lecture in the classroom is that this enables use to be made of colored materials, which the black and white TV system at Buena Vista does not permit. And sometimes the teachers may schedule supervised study or a test.

On the days that no telelesson is given, the class is typically split into three subgroups. Each of two of the subgroups forms about 25% of the total group. These are taken into smaller rooms, where discussions are held. The remaining 50% may continue to meet in supervised study, or in some similar activity. Most of the lecturing is done via television, but the discussions are carried on entirely in the smaller groups.

The Buena Vista High School building, of brick construction, was built in 1959. The school is interesting in regard to space allocation. It has only five conventional classrooms. Much of the space at Buena Vista High School is in large lecture rooms with as many as six television monitors in a single room. These rooms can be (and often are) subdivided into two smaller rooms to increase space flexibility. Personnel who directly support television include a full-time professional television director who reports directly to the school administration. He directs all telecasts, trains the student crews who operate the cameras, and administers his department. He is supported in his efforts by a production assistant and a studio artist. The assistant maintains the equipment, directs some of the programs, and may, if required, take the place of the director. The artist prepares original visual aids for telecasting and maintains a file of pictures and films for the use of teachers.

Appendix F (cont)

In preparing for a telelesson, the teacher writes three documents: (1) a lesson plan as his own guide; (2) a script form for the use of the television crew during the telelessons; and (3) a "request for visuals" for use by the artist. Since the lesson plan is used by the teacher, it can be as brief or as detailed as he desires. The other two forms must be clear and complete enough to give proper direction to the television personnel. Both the script and the request for visuals are submitted to and, if necessary, discussed with the television director. The request for visuals, which must be turned in at least two days in advance, is given by the director to the artist who either takes appropriate visuals from his files or constructs them. The visuals must be completed and in the teacher's box at least two hours before air time so that he may check them and return them to the director.

The script form has spaces for the teacher to write the title of the subject; the teacher's name; the date and time of the presentation; the video sequence in chronological order; and a sentence outline of the presentation. This document serves as a guide for the director who studies it and fills in the telelesson camera schedule.

Telelessons are scheduled for each school period. Since a telelesson normally lasts one-half period, there is a "break" between each broadcast so that the director can make final preparations for the next telelesson. During this break, he picks up visuals and checks equipment, cameramen, and actors. Just prior to air time the instructor who is to present the telelesson appears at the studio. Thirty seconds after the last class bell rings, the presentation begins. When the bell rings, the students are expected to be in their seat with note-taking materials ready. Upon completion of the telelesson, the instructor makes notes for his future use on the script form.

The amount of time required on the part of television personnel for any given course depends on the nature of the course and the experience and demands of the teacher. For 11th-grade English, the following estimates were made by the team leader:

Function	Time (in hours per week)
Preparation	.5 to .75 (runs much higher for an inexperienced teacher)
Setup time	.5
Running time	1.25
Constructing Visuals	6 - 7
Total	8.25 to 9.50

Appendix F (cont)

B. PROBLEM

The Buena Vista High School study was conducted to determine the implications of its approach to instruction for the five major areas of interest that guide the project, New Solutions to Implementing Instructional Media Through Analysis and Simulation of School Organization. These five objectives are summarized below:

- Definitions of new roles for school personnel.
- Information on the effects of new media.
- New applications for data processing.
- Information on the use of space.
- Estimates of the characteristics of graduates.

The 11th-grade English course at Buena Vista was selected as exemplary of the school's approach to instruction. In this course, a telelesson is presented for about one-half of a regular school period on Mondays, Wednesdays, and Fridays. Instructional personnel associated with the course include the team leader, a second teacher, and an intern. The lesson is presented to about 150 students in a large room containing six television monitors. After the telelesson, the instructor can use the remainder of the period for live lectures in the classroom, oral quizzes followed by discussions, a test or exercise, or a study period. Usually the large group remains intact, but about 5% of the time it is split into either two or three smaller groups.

On Tuesdays and Thursdays, the total class may either remain together or be split into three groups. When it remains together, the students usually spend the full period on independent study; however, they may take a test, listen to a lecture, or get involved with the teacher in a discussion. About 60% of the time, the Tuesday and Thursday classes are split into three groups and the period is spent in discussion.

C. METHODS

The study of the 11th-grade English course at Buena Vista High School used two sources for data. The first involved visits to the school during which data were collected in order to produce a system analysis of the course. The second made use of computer simulation to produce data describing the operation of a simulated course.

Appendix F (cont)

The system analysis phase of the study followed the general procedures presented in Chapter II of this report. Two documents (References 16,17) resulted from this effort, one providing a description of the school as a whole, and the other providing a detailed system analysis of the 11th-grade English course. This information was summarized in sections A and B, above. As part of the system analysis, the course was formulated as a system for processing the class through the various activities that describe the course. This analysis defined five kinds of activities that consume the resources of the course as well as the rules* that ultimately result in the selection of a specific activity for the class as a whole.

This system was modeled on a computer by using the simulation vehicle described in Appendix B of this report. The procedure was to enter the class into the first activity of the model and allow the computer to select subsequent activities based on the rules defined for the system. This continued for a simulated 175 days, when the simulation was concluded. The simulation resulted in a data tape on which was recorded the history of the class as it went from one activity to the other. In addition, the length of time spent in each activity was recorded on this tape.

D. RESULTS

Five general activities were used to describe the 11th-grade English course at Buena Vista. These were:

- Lecture delivered by closed-circuit television.
- Panel or other similar activity using the television medium.
- Discussion, recitation, or classroom lecture.
- Test, correcting tests, or review of tests.
- Independent study.

*The term "rule" has a precise meaning in the context of system analysis and simulation. It refers specifically to the probabilities associated with alternative choices that may be made at a specific decision point.

Appendix F (cont)

Most of these activities had a possibility of occurring in connection with the class when it was in a large group or in a split group arrangement. In addition, each activity could last for either a half period or a full period. Table I shows the frequency with which each activity occurred in the actual class in terms of the size of group and the length of time involved. Of particular interest are the fifth and sixth columns from the left; these columns summarize how the total time in the course was spent. The column labeled "Equivalent Days" shows how the 175 days of the course were divided among the activities. The column labeled "% of Total Time" shows the same information expressed as a percentage of the total.

The column on the extreme right of Table I shows data produced by simulation; these data are summarized in terms of the way the class spent its time in the various simulated activities. The data are expressed as a percentage of the total time (175 simulated days) and can be compared to data from the actual course appearing next to it. The two columns are very similar both with respect to absolute values and over-all pattern.

E. DISCUSSION OF SIMULATION

The rules used for simulating the 11th-grade English course ultimately determined the specific activity for the class. Moreover, they determined the size of the group and the length of course time consumed by the activity. To the extent that the data produced through simulation agree with the data from the course, confidence in the model used for simulation is strengthened. Agreement was reported with respect to the over-all proportion of time spent in each activity.

This model served two purposes. One purpose related to its value as an abstraction that characterizes the 11th-grade English course; the other pertains to its utility as an experimental vehicle. As to its value as an abstraction--an examination of the model discloses some interesting but not startling facts: For example, the selection of a particular activity for the class depends on whether or not the last activity was a telelesson plus a determination as to whether the new activity is for a large group or a split group. This dependence implies that the ultimate activity that students engage in is dependent both on media (television versus non-television) and on the size of grouping.

This analysis points to two conclusions: First, the question of media is of primary importance and takes precedence over the size of group; second, the size of group in conjunction with media takes precedence over the particular activity in which the class engages. As suggested above, this conclusion

Appendix F (cont)

Table I. Activities in 11th-Grade English

Activity	Size of Group	Actual Course: Number of Occurrences: Half Period	Full Period	Equiv-alent Days	% of Total Time	Sim. Course: % of Total Time
Lecture via TV	Large	72	01	37.0	21.1	22.9
	Split	--	--	--	--	--
Panel, etc. via TV	Large	19	01	10.5	06.0	06.0
	Split	--	--	--	--	--
Discussion, Recitation or Lecture	Large	19	09	18.5	10.6	11.5
	Split	06	44	47.0	26.9	25.7
Test, etc.	Large	34	04	21.0	12.0	10.0
	Split	02	--	01.0	00.5	01.0
Independent Study	Large	25	21	33.5	19.1	20.9
	Split	05	04	06.5	03.7	02.0
Totals		182	84	175.0	99.9%	100.0%

Appendix F (cont)

is hardly startling when one considers that Buena Vista is dedicated to the use of team teaching and closed-circuit television in their approach to instruction. The model does, however, make this quite explicit.

A second purpose that might be served by a model of the 11th-grade English course is to assess the effects of change. What, for example, would be the consequences if telelessons were either curtailed to two or increased to four per week? Either of these two experimental versions of the course could be formulated in terms of the model and results could be simulated. It would thus be possible to assess the effects of proposed changes to the course before changes are actually made.

F. IMPLICATIONS OF THIS STUDY FOR PROJECT OBJECTIVES

The data from the present study having implications for the New Solutions project came from two sources. One is the descriptive data collected from personnel at Buena Vista High School and the other is the data resulting from the use of system analysis and computer simulation techniques. The following discussion uses both sources of information.

1. New Roles for Personnel

In the Buena Vista approach to instruction, teachers are placed in "stimulator" and "dispenser of information" roles. The school adopts the position that some teachers are much better qualified than others to stimulate students and to impart information. Furthermore, if the teacher is going to lecture anyway, he may as well lecture to a large group as to a small one. Therefore, teams have been formed in which the roles of the various members differ considerably.

In the 11th-grade English course at Buena Vista, the team leader does the lecturing. In order to accomplish this in connection with the closed-circuit television medium, he must prepare scripts and specify visual aid materials. In addition, he must take a strong interest in techniques of the medium and be constantly in search of ways that can use it better. The other two members of the team take roll and serve as proctors in the large classroom while the leader is presenting the television lecture. In addition, the latter two conduct discussions when the large class is divided into smaller groups. In this role, skills for leading group discussions are mandatory.

2. Effects of Media on Student Interaction

As a medium, television necessitates skill in listening on the part of students. Communication is one-way, from the presenter to his audience. Interaction

Appendix F (cont)

between student and teacher is virtually nonexistent during telelessons. Buena Vista High School has attempted to alleviate the effects of this problem by providing an audio channel between the classroom and the television studio so that classroom response is audible to the teacher. It is thus possible for students to direct questions to the teacher during a television presentation, but two factors mitigate against the likelihood of this occurring. One is due to the obvious distance between students and the teacher. Many students are reluctant to address a microphone in the presence of 150 other students when they are not visible to the teacher. Another factor is due to the student being in a well defined and often practiced role of television viewer. This role calls forth attitudes of passive receptivity rather than active participation.

The over-all Buena Vista High School approach to instruction compensates for the limitations on interaction imposed by television by providing ample discussion time. In the 11th-grade English class, for example, more than one-third of the total class time is allocated to interaction involving a teacher and students as a group. Much of this time is structured by the teacher as a lecture or recitation, but some time is devoted to discussion.

3. New Uses for Data Processing

It is not the intent of this study to catalogue the general needs that a school may have for improved information processing. Instead, the project has focused on a specific instructional organization, such as the 11th-grade English course at Buena Vista, with an eye to its improvement through the use of information processing techniques.

The system analysis has shown that a specific activity in the English course can be selected by a general system that makes two simple decisions (see Section E, above). In actual practice, a specific course activity is selected by consulting a course lesson plan that lists each activity, the associated content to be covered, and the time in minutes to be spent on the activity. The plan provides a complete structuring of student time for the whole year in terms of his assignment and course activity and each student is treated alike.

One way that information processing can be used to improve the present 11th-grade English course is to provide a formal feedback loop from student performance to the course plan. This system could provide the course designer with information so that he could select the most effective activity (telelesson, small group discussion, etc.) to meet the objectives relative to the specific content presented on a certain date. The point of view taken here is that the designer of the course plan must decide which of the possible activities are best suited to meet specific content objectives. He can base this decision

Appendix F (cont)

on convenience, or intuition, or on data from some system he might devise for collecting student performance data. For example, the course designer could state the behavioral changes in student performance that he intends to effect in a given telelesson. The degree to which the lesson is effective can be measured by a test following the telelesson. These data can be stored and used in a revision of the course for the following year.

A second use for information processing might emerge as a result of a general change in the present course plan that would allocate some or all of the small group time for helping students who need assistance in the course. Effective use of this time would require information on the specific needs of students for assistance. Such information could come from performance data like that described in connection with the problem of course design discussed above. Actually, the same data could serve both purposes. If a teacher had such data prior to a small group session, he could plan the session to include a lecture to the total group in response to a common need, remedial pencil and paper exercises, or individual tutoring to selected students while others study.

4. Uses for Space

The use of closed-circuit television as a medium of instruction at Buena Vista High School requires certain amounts and arrangements of space. Telelessons are presented to groups ranging in size from 70 to 155 students. The students sit in one large room viewing television monitors placed at the sides of the room. Obviously it is mandatory that each student have a clear and unobstructed view of a monitor and that the sound system and classroom acoustics be so engineered that each student can hear well. Any school contemplating the use of closed-circuit television for instruction should consult with audiovisual experts in designing a telelesson facility to meet their specific needs.

Additional space requirements exist in the studios used for production and broadcast. Approximately 3,000 square feet of space are devoted to two studios at Buena Vista High School. One contains television cameras, equipment for audio recording, equipment for projecting movies and films, lighting, and transmission equipment. The other room is for preperation and contains audiovisual equipment of many sorts, a photographic darkroom, and files of charts, maps, pictures, etc.

Team teaching requires areas for large group instruction, small group discussion, and individual study. The space needs for large group instruction and telelessons coincide as far as students are concerned. The space requirements for individual study are still not fully understood. Some schools feel that individual space (study carrels) are needed while others believe that study is best accomplished in a large room with every student in view of the

Appendix F (cont)

teacher. The latter procedure makes space more flexible because it can be used for large group instruction and for independent study; this is what is done at Buena Vista High School.

Small group discussions in the usual meaning of the term are not possible in the 11th-grade English course because the groups usually include 30 to 40 students. Two resources limit the number of groups that can be formed from the large class--the fact that the English course has only three teachers available for leading the small groups, and the lack of space facilities to accommodate numerous small groups.

These problems are not insoluble. For example, some schools use student teacher-assistants in similar situations; in addition, portable screens could be used to divide a large classroom into small discussion areas. Probably the major underlying problem is that the function of the "small" group has not been defined as a true discussion group but remains instead a teacher-centered classroom. If this definition of the area is used, the present space is probably satisfactory.

5. <u>Characteristics of Graduates</u>

The general treatment of students in the instructional process at Buena Vista High School does not appear to be substantially different from most high schools; the main difference is that the typical functions of large group instruction, discussion, and independent study are more sharply delineated at Buena Vista. There is no reason to expect that the approach to instruction at Buena Vista High School will have an effect on students that is noticeably different from the effects of other typical high schools.

G. TELELESSONS COMBINED WITH CONTINUOUS PROGRESS

Two opposing trends in organizing instruction were noted by the authors during this project. One leads toward group instruction and the use of mass media such as television, and the other leads toward individualized instruction and the use of self-study materials such as programmed instruction. The possibility of combining both kinds of media into one course that is part teacher-centered, part individual-centered and yet permits students to progress at varying speeds through a course appears attractive to the authors. Such a prospect could retain the value derived from very good teaching in the conventional sense yet allow students to vary in the progress they make depending on their individual abilities and commitments to a course.

Appendix F (cont)

In connection with the study of the English course reported above, project personnel in concert with Buena Vista High School personnel have designed a plan for a course that combines telelessons with individual progress (Reference 18). In the proposed program, 11th- and 12th-grade English would be taught as a single continuing course. Some students can finish this normal four-semester course in three semesters while others can take four or five, depending on their ability.

Large group instruction time is allocated to the following activities during each two-week period:

• diagnostic test	--	25 minutes
• two telelessons (one each week)	--	50 minutes total
• two small group discussions	--	50 minutes total
• directed study	--	75 minutes total
• a unit test	--	25 minutes

Individual progress instruction time is allocated as follows:

• a diagnostic test	--	25 minutes
• a film tape or record	--	25 minutes
• directed study	--	200 minutes
• a unit test	--	25 minutes

APPENDIX G

SYSTEM ANALYSIS AND COMPUTER SIMULATION OF THE MATHEMATICS CURRICULUM AT GARBER HIGH SCHOOL

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Appendix G

A. INTRODUCTION

Garber High School, located in Essexville, Michigan, is a six-year combined junior-senior high school. The school opened in the fall of 1964 and at the present is midway through its second year of classes. There are 685 students attending Garber; this number is expected to increase to about 900 within the next three to four years. A superintendent, an assistant superintendent, and a head counselor have their offices in the high school and serve the total system that also includes three elementary schools. The high school proper has an assistant principal and an instructional staff of 35.

The expressed educational objective at Garber High School is that "the individual learner should be permitted to move through as much subject matter as he can master" (Reference 3). In striving to attain this objective, the school is implementing several innovations as rapidly as resources permit. Two of these innovations are incorporated into a plan which the mathematics department* put into operation during the current (1965-66) school year. These innovations are: (1) to organize courses so that students may progress through them at different learning rates; and (2) to provide parallel versions of basic courses to accommodate students with different ability levels.

An outline of this plan is presented in Table I. The department offers 29 different courses. Many of the courses may be completed in various lengths of time, depending on the individual ability of a student. Courses may be completed at various times in a range between 90 and 270 days, depending on the particular course. Some courses, particularly those offered to the very young students, have no possibility of variable time while others have at the most, three possibilities. Table I shows the variations for each course.

This feature can have important consequences on the number of courses that each student takes in mathematics. A fast learner may finish a course and begin the next one before a regular school year ends. By spending the minimum possible time in each course he takes, a fast learner can take several more than the customary one course per year while he is in high school. The slow learner, on the other hand, can take a fewer total number of courses by requiring the maximum length of time to complete each course. The advantage to the slow learner is that he can attain a higher degree of mastery over the material by taking more than one year to complete a given course.

*At the time of this report, the Garber High School mathematics department consists of a chairman and four instructors conducting classes for 588 students.

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Table I. Summary of Courses Given by Garber High School Mathematics Department

Course No.	Description	Possible Variations in Length (Days)	Parallel Version (Course No.)	Choices Upon Completion (Course No.)
Math 100	Pre-Algebra I	180	101,102	200
Math 101	Pre-Algebra I and II	180	100	201
Math 102	Functional Mathematics I	180	100	202
Math 200	Pre-Algebra II	90,180	202	306,300,301
Math 201	Elementary Algebra	135,180	---	400,401,501,305
Math 202	Functional Mathematics II	180	200	300,301,302
Math 300	Practical Mathematics	180	302,303	400,301,406
Math 301	Elementary Algebra	135,180,225	303	403,401,405,501,503,500
Math 302	Functional Mathematics III	180	300	---
Math 303	Selected Concepts of Elementary Algebra	180,270	300,301	400,403,503
Math 305	Independent Study in Mathematics	90,180	---	403,401,405,501,503,500
Math 306	Independent Study in Practical Math	90,180	---	400
Math 400	Technical Mathematics I	180	---	506,500,503
Math 401	Advanced Algebra	135,180,225	403	603,501,505
Math 403	Selected Concepts of Advanced Algebra	180,270	401	500,503
Math 405	Independent Study in Mathematics	90,180	---	603,501,505
Math 406	Independent Study in Practical Math	90,180	---	506,500,503
Math 500	Technical Mathematics II	180	---	501,606
Math 501	Plane and Solid Geometry	135,180,225	503	603,601,605,401
Math 503	Selected Concepts of Geometry	180,270	501	603
Math 505	Independent Study in Mathematics	90,180	---	603,601,605,401
Math 506	Independent Study in Practical Math	90,180	---	606,501
Math 601	Advanced Mathematics	135,180	---	701,705
Math 602*	Review of Basic Arithmetic Skills	90,180	---	---
Math 603	Continuation of 303, 403 or 503	90,180	---	601
Math 605	Independent Study in Mathematics	90,180	---	701,705
Math 606	Independent Study in Practical Math	90,180	---	---
Math 701	Calculus	180	---	---
Math 705	Independent Study in Mathematics	90,180	---	---

*602 is required for those students failing to pass mathematics abilities test given during fifth year.

Appendix G (cont)

A second feature of the Garber High School plan in mathematics is to provide parallel versions for some courses to accommodate different ability levels of students. One such course emphasizes theory while another covers the same basic concepts and emphasizes practice. About half of the 29 courses have a single parallel version; three of the courses have two alternates. Garber High School has a procedure whereby a student who is working in a course that is deemed inappropriate for his abilities can be moved to an alternate version without completing the original course. Table I shows the parallel versions for each course.

The combination of variable time and parallel courses can serve a range of student abilities. For example, elementary algebra is taught in both Math 301 and 303. Students may complete Math 301 in 135, 180 or 225 days and Math 303 in 180 or 270 days. Thus, there are five versions of elementary algebra available for Garber High School students. In addition, a student may begin Math 301 and move to Math 303 or he may begin Math 303 and move to practical mathematics (Math 300). When he finishes Math 301, he has a choice of five courses as his next work. Math 303 equips him for three choices, and Math 300 limits his choice to two. Table I shows the courses that may be chosen when each course is completed.

B. PROBLEM

Full utilization of the Garber High School plan must wait until the present first-year students* have had exposure to the full possibilities offered during the six years they will be in the school. The problem posed for this specific study is to discover the implications that predictions about the results of this plan have for the five major areas of interest that guide the overall project, New Solutions to Implementing Instructional Media Through Analysis and Simulation of School Organization. Briefly, they are to:

- define new roles for school personnel;
- provide information on the effects of new media on student interaction;
- describe new applications for data processing;
- provide information on amount and arrangement of space; and
- provide estimates of characteristics of students graduating from the school.

*Students are classed by the number of years they would normally have spent in the school beyond the elementary grades. First-year students would be called seventh-graders in traditional schools.

Appendix G (cont)

C. METHODS USED

The system analysis of the Garber High School mathematics department was done in three phases. The first was to visit the school and collect data describing the organization of the mathematics department and the procedures used for operating it (descriptive phase). The second was to formulate these data into a model that regarded the department as a system for processing students (formulation phase). The third was to simulate the progress of students as they moved through this model in imitation of the behavior of actual students (simulation phase).

The descriptive phase followed the general procedures discussed in Chapter II and resulted in two documents that described the school and the mathematics department (References 3, 4). These data were summarized in Section A, above. The formulation phase focused on the production of a model that describes all of the possible pathways students might take through the mathematics curriculum as they move from one course to another. In this analysis, each of the 29 courses is visualized as consisting of two activities: (1) working in the course; and (2) receiving credit for it. Each of the resulting total of 58 activities is associated with a specific control point. Some control points represent branches where students have a choice as to their next course, others represent variable time in a course and still others represent combinations of multiple choices and variable time. With this model, a logical history can be constructed for a particular student by tracing a pathway from control point to control point, assuming that he meets the necessary conditions to advance along a particular pathway. This model, shown as a flow diagram and the rules associated with its use may be examined in detail in project documents (Reference 3).

The simulation phase of the study consisted of simulating the model that had been formulated on a computer. The EDSIM vehicle developed for this project was used for simulation. It is described in Appendix B of this report.

The problem posed for the Garber High School simulation study was to simulate the progress of students through the model in order to determine the demands that would appear for the various courses represented in the model. It is of practical interest to learn how students will distribute themselves into the 29 mathematics courses when the plan has been in operation for six years.

The procedure was to distribute 100 simulated students into their first-year courses according to estimates made by school officials. These students were processed by the simulator for 180 simulated days (one school year). During this time, some moved to parallel versions of the courses in which they began; on day 180 all students completed the course they were in and moved to the next year's courses. On day 181, a second group of 100 began their first-year's

Appendix G (cont)

studies. On simulated days 361, 541, 721, and 901, four more groups of 100 students began their work in the first-year courses as the older students moved on through the system. At the end of 1,080 simulated days, the first group of 100 students had completed six years of simulated study while the others had completed 5, 4, 3, 2, and 1 years, respectively. At this point in simulated time, each activity in the model had an opportunity to be used, and the simulation was concluded.

D. RESULTS OF SIMULATION

The data descriptive of the mathematics department collected at Garber High School were used as a basis for Section A, above. The formulation of these data into a model for processing students was described in Section C. This section presents the results obtained from simulating the model.

1. June, 1971 Enrollment in Courses by Student Level

The first result from simulation was data predicting the total enrollment for each of the 29 courses in June, 1971. The enrollment in each course was then analyzed to show how many students from each student level were in each course. These results are shown in Table II. The row labeled "Term. Math" shows the number of students who were in school but not enrolled in a mathematics course in June, 1971. The bottom row shows the total number of students in school as of June, 1971. This figure was obtained by taking the size of the actual current first-year class (124 students) and postulating an approximate 10% annual increase in the size of subsequent first-year groups. School officials estimate that the Garber enrollment will be about 900 in three to four years.* These data predict that by June, 1971, 745 students will be enrolled in mathematics (inferred from Table II as the difference between "Total Enrollment" and "Term. Math").

In almost every instance where a course above the "300" series has an enrollment of over 10 students, the course is made up of students from the third-year, fourth-year, fifth-year, and sixth-year levels. The exceptions contain students from three levels. This vividly illustrates the capability of the model to simulate the "nongraded" structure of classes as envisioned by the Garber High School plan.

*The procedure used in simulation was to use 100 students for each of the six groups described in Section C. In the results reported in this chapter, each simulated student in the first group is assumed to represent 1.24 first-year students, each simulated student in the second group of 100 represents 1.37 second-year students, etc.

Appendix G (cont)

Table II. Predicted Enrollment by Course

Course No.	June 1971 Enrollment	Enrollment Distribution by Student Level					
		Sixth Year	Fifth Year	Fourth Year	Third Year	Second Year	First Year
100	114						114
101	42						42
102	44						44
200	103				02	101	
201	55					55	
202	30				03	27	
300	11				11		
301	36			03	33		
302	02				02		
303	11			01	10		
305	--						
306	--						
400	11	01		03	07		
401	51	07	07	21	16		
403	32	05	06	10	11		
405	02				02		
406	--						
500	15		04	03	08		
501	64	03	14	23	24		
503	21	01	07	05	08		
505	06		03	01	02		
506	02		01	01			
601	37	05	10	17	05		
602	09	01	03		05		
603	26	08	02	13	03		
605	--						
606	--						
701	21	09	04	08			
705	--						
Term. Math	217	84	76	42	15		
Total Enroll-ment	962	124	137	151	167	183	200

Appendix G (cont)

2. Mobility of Students

Simulated data bearing on the question of how frequently students will move from one course to another when the Garber plan is fully operational are shown in Table III. These data result from comparing the enrollment totals appearing in Table II with similar totals produced three simulated weeks earlier. In both cases 962 students are involved, the difference being the way they were distributed into the 29 possible courses at the two points in time. These data show that the enrollment in 14 courses changed during this time period. Six courses gained a total of 27 students and eight courses lost a total of 44 students. Seventeen were added to the "Term." category, i.e., they stopped taking mathematics courses. Thus, a minimum of 88 students moved in or out of a course during this period. The minimum qualification is necessary because the figures represent net differences. More movements could actually have occurred.

E. IMPLICATIONS OF RESULTS

The data used in the following discussion came from all phases of the system analysis and from the predictions made by simulation. This raises a problem as to what part of the discussion reflects the actual situation at Garber High School and what part is speculation guided by simulation. The authors will attempt to distinguish procedures presently in use from those that appear to be required in order to make the plan operable.

1. Definition of New Roles for Personnel

The tasks faced by an instructor in a classroom that is operating under the fully implemented plan may be partially inferred from the data used to formulate the model. From the instructor's viewpoint, most courses never begin or end in the traditional sense; they operate continuously. Students in small groups of from two to 10 come into and leave a course every 45 days (Table I shows those courses with variations in length). Since students will come and go in this fashion, there is a possibility in a course that some student is working at any given point in the sequence of content on any particular day. This implies that an instructor must be equipped to help students on any specific part of the full range of content in a course, at any time. Moreover, the data from simulation show that most courses above the 300 level will contain students from the third year through the sixth year (see Table II). Consequently, instructors in these courses must also be prepared to deal with the age differences in students.

Appendix G (cont)

Table III. Changes in Course Enrollment During Last Three Simulated Weeks

Course Number	Early June Enrollment	Late June Enrollment	Gain	Loss
100	114	114		
101	42	42		
102	44	44		
200	103	103		
201	55	55		
202	30	30		
300	15	11		04
301	27	36	09	
302	04	02		02
303	22	11		11
305	--	--		
306	--	--		
400	18	11		07
401	57	51		06
403	25	32	07	
405	--	02	02	
406	--	--		
500	15	15		
501	64	64		
503	28	21		07
505	03	06	03	
506	--	02	02	
601	40	37		03
602	13	09		04
603	26	26		
605	--	--		
606	--	--		
701	17	21	04	
705	--	--		
Term.	200	217	17	
Totals	962	962	44	44

Appendix G (cont)

The Garber High School mathematics department has evolved a partial solution to this problem in large classes by grouping students according to their instructional needs. For example, about 170 students are presently enrolled in Math 301. The course meets with five instructors in five separate rooms. Students are assigned to a particular instructor on the basis of the particular concepts in the instructional sequence on which they are currently working. Thus one instructor will have those students who are working on concepts one and two, another instructor will have those students working on concepts three and four, etc. Students are freely moved from one group to another as their individual relationship to the total group shifts. This practice restricts the range of concepts over which an instructor must be prepared to teach by providing him with a group that has similar instructional needs.

Individualized instruction implies a drastic redefinition of the conventional instructor's role. The variable length of courses as planned at Garber High School, with the resulting movement of students in and out of courses, is possible only because the responsibility for presenting content has shifted from the instructor as a lecturer to media that can be used in an individual mode. The instructor's role is directed instead, to consulting with individual students. Consultations are for defining problems that students may have with understanding the learning materials used in a course and for advising remedial learning experiences to aid in solving these problems.

The role of student in the school implied by the Garber High School model also differs from a conventional school. At Garber High School the student must make many decisions that are made for him in traditional classrooms. For example, he decides when he is ready to be tested and, in general, is permitted to select his specific daily activities from the list that appears in a study guide. The amount of time he spends in completing a variable length course (and consequently the number of courses in mathematics that he completes during his high school career) reflect his view of the importance of mathematics plus his own abilities. Extra work at home or school is directly applicable to his progress.

The chairman of the mathematics department plays an important role in the Garber High School scheme. He is the individual who gives the department its unified and coordinated approach to instruction. He enlists the aid of the remainder of the staff in producing materials (study guides, tests, etc.), in selecting media (texts, etc.), and in formulating procedures for organizing instruction on a department-wide basis. No small part of his job has been the definition of the instructors' roles and their training in the skills needed to perform in the Garber High School system.

Appendix G (cont)

2. Effects of New Media on Student Interaction

Study guides and mastery tests, while not instructional media in the strict meaning of the term, are basic to the use of media at Garber High School. A study guide tells students what they must do to accomplish the objectives of a course. Directions are given in explicit detail. The guide is written so that a student can begin a course at any time by following its directions, and it leads him step-by-step through the course. For any given division of the course (concept or unit are the usual descriptive terms), a guide may direct a student to a variety of media for his instruction. For example, he may be directed to read sections from one or more texts, work some specific exercises, view a particular filmstrip, listen to a taped lecture, consult with the instructor on a specific point, etc., all in connection with the same unit of study. When the student has completed all of the activities prescribed for a particular unit by the study guide, he is directed to request the mastery test for the unit. Mastery tests evaluate whether or not the student has achieved mastery of the unit objectives. At Garber High School, mathematics students can usually take a second test after remedial study if the initial test results are unsatisfactory.

The use of study guides in all mathematics courses at Garber High School has implications for the amount of student/student and student/teacher interaction that will occur. To the extent that interaction is viewed as an objective for a specific unit of study, it can be programmed into the course. The study guide for Math 301, presently in use at Garber High School contains such provisions. In most of the units covered by this guide, students are required to form a small discussion group with others working on the same unit to discuss a specific topic. In addition, the student using the guide is often reminded to ask the instructor for clarification if he does not understand a specific point. Perhaps a more effective procedure would be to require students to consult with the instructor at certain points in the instructional sequence. As a result of using study guides to organize instruction, student/student and student/teacher interaction is not left to the whims of a particular instructor's style for conducting a classroom. Instead, interaction may be planned in order to achieve specific objectives of the course.

3. New Applications for Data Processing

Simulation shows two pieces of data that have important implications for information processing usage: (1) of the 745 students enrolled in courses in the spring of 1971, at least 88 will move from one course to another during a three-week school period; and (2) if and when all 29 courses in mathematics are individualized, there will be a need to administer about 10,000 mastery tests per year.

Appendix G (cont)

Extrapolating these data to the total school where a given student takes five courses like those simulated in the study of the mathematics department indicates that the bookkeeping job is awesome, indeed. If the school intends to operate all courses as it operates those modeled in mathematics, it can anticipate that 30 to 40 students will transfer from one course to another on any given day and that approximately 300 mastery tests must be administered daily.

One of the major deterrents to innovation in the direction of individualization is the magnitude of the bookkeeping job it implies. Project personnel in connection with their study of Brigham Young University Laboratory School (reported in Appendix C) and Theodore High School (reported in Appendix E) have observed this problem in those contexts. A general solution to this problem has been proposed by project personnel (Reference 20). The solution is in the form of a proposed design for an information processing system to be used in conjunction with individual progress courses. The proposed system uses modern data processing technology to (1) predict the expected behavior of individual students; (2) to record their day-to-day progress in all courses; and (3) to produce displays of information for students, instructors, counselors, and other school officials that can be used to help make decisions about appropriate actions. The system can be also used for ancillary tasks such as scoring tests, producing reports, and maintaining an up-to-the-minute cumulative record on each student.

4. Information on Amount and Arrangement of Space

There are several functions performed by students and instructors in the mathematics department that appear to have different space demands. Each is discussed below:

a. Space for Individual Study

Data from simulation predict that the present procedure of having students study in regular classrooms with an instructor present to give assistance will require about 33 classrooms if the classes meet daily. If they meet on Monday, Wednesday, and Friday in some classes and Tuesday and Thursday in others, the daily demand for classroom space can be cut in half. The present flexibility at Garber High School whereby classroom space can be adjusted by opening and closing partitions appears to anticipate the variety of classroom sizes predicted by simulation.

Appendix G (cont)

b. Space for Testing

The predicted requirement to give an average of 55 mastery tests daily indicates that the present facility accommodating 25 students simultaneously will probably suffice, if the average is a good estimate of the daily demand. Maintaining a steady flow assumes that all courses are operating on an individual progress basis.

c. Space for Student/Instructor Consultations

Student/instructor consultations are presently held either in the classrooms while other students are in individual study or in the general teachers' office. The general teachers' office is a large open space in which all Garber High School teachers have their desks. In both cases, consultation shares space with other functions. Since consultation is viewed as a major task of instructors in individual progress courses, project personnel recommend that attention should be paid to the space requirements for this activity and that the allocation of space be reviewed in the light of these requirements.

d. Space for Instructors' Administrative Work

The desks for the five instructors in mathematics are clustered so that each person faces the others. Although this arrangement conserves space in the general office area (shared with all other instructors in the school), it sacrifices any semblance of privacy so that a teacher can concentrate on his work. This space also is used for student/teacher consultation outside the classroom. Consequently it is not unusual for one or more of the five instructors to be consulting with students while others are grading tests, posting records, or composing class materials.

Probably the major reason why common space is used for dual functions in the mathematics department is that personnel, and not space, are lacking. For example, group discussion, student/teacher consultations and individual study occur in the same room because there is only one instructor available to supervise all three activities. The school has excellent facilities for small group discussions and for consultation but these are fairly remote from the classroom. Arranging for discussions and consultation to occur remotely poses scheduling problems. A solution would be to develop a system that would bring students together for group discussions and that would enable a student and teacher to consult in some space appropriate for these activities. This system should be able to accept requests from students for meetings, and should prepare and issue a schedule. While it is quite feasible to do this scheduling manually, the computer-based system mentioned in E,3, above, could handle this

Appendix G (cont)

task along with many others. Such a system implies that it may be possible to set aside a block of time independent of instruction and administrative work in which discussion and consultation can occur.

5. Estimation of the Characteristics of Graduating Students

The data from simulation predict that the students graduating from Garber High School in June, 1971 will have earned a total of 607 course credits in mathematics in 24 different courses. This represents an average of 4.9 courses per student. About 32% of the class of 1971 will be taking mathematics when they end their high school careers. About 16 members of the class will have completed or be enrolled in calculus (Math 701).

APPENDIX H

PALO ALTO COUNSELING STUDY

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Appendix H

A. INTRODUCTION

The work performed in this study has a different set of educational objectives than the system analysis studies conducted at innovative high schools and reported in Appendixes C through G. This project deals with a counseling function rather than with an instructional function. The specific problem area selected for study was the educational planning function. The methodology employed was to explore the application of information processing technology to this function by constructing computer simulation models of a counselor helping children in their educational planning.

This first study was conducted to identify some major problems for further research and to develop a methodology. Because of its exploratory nature, this study was aimed at a broad spectrum of counselor behavior. We attempted to simulate both a counselor's behavior in the appraisal of students' cumulative records and his behavior in the educational planning interview. We hoped that the study, in addition to suggesting further areas for research, would provide some concrete information about the kinds of man-machine systems that can be designed for counseling services.

Before selecting a counselor, we were concerned with several problems. Could a counselor be selected on some external criterion? We decided that, since we wanted to study such a broad spectrum of the counselor's behavior, there were no existing criteria for operationally defining the "best" counselor. We decided instead to study counselors who were considered "good" by their supervisors.

A second question concerned the generalizability of our study. We had made recordings of the verbalized "thoughts" of counselors from different parts of the country as they appraised cumulative folders. These pilot studies showed that there are fairly wide differences among counselors. Some counselors concern themselves almost entirely with the data in the cumulative folders; others talk about the phenomenal experiences of the student as expressed in previous counseling interviews. We next considered studying several counselors at the same time, but decided that for this first exploratory study we should examine one counselor intensively. We then selected an experienced counselor who habitually used the data in the cumulative folder in his appraisal.

Since the task was to help ninth-grade students in their planning for high school, we picked a counselor who had experience in this task and who also worked at the high school level. Our rationale for the latter decision was the assumption that a counselor who had worked with high school students might, consciously or unconsciously, have developed better predictive rules from exposure to the students in the criterion situation.

Appendix H (cont)

The counselor selected for the study had long experience in the Palo Alto School District. He was identified by the Director of Guidance and the Director of Research of the school district as one of their best counselors, and was also working as a vice-principal in one of the high schools.

The following procedures were employed in the data collection. The cumulative folders of 20 ninth-grade students were randomly selected for the study. The counselor was instructed to think aloud as he read through the data in each folder. He was asked to select the data he felt were important and to address himself to the following problems:

- What broad goals should the student consider?
- What problems, if any, does the student have?
- What additional information would be desirable?
- If problems are apparent, what causes might be hypothesized?
- What things might the school do to help the student?

The only other instructions given to the counselor were that he should notify us when he was about to express his conclusions and that he should label these as his "output" statements since we wanted to use these statements, word for word if possible, as the output statements of the computer program.

Following the appraisal of the cumulative folders, the counselor called the students in for a regular educational planning interview, during which the students made out a program of courses for high school.

The separation of the appraisal from the interview was somewhat artificial. Most counselors, including the subject of this study, make their detailed appraisal during the interview and not prior to it. However, the artificial distinction was necessary for the study.

The recordings were transcribed and analyzed. A model of the counselor's decision rules in the appraisal task and another model of his behavior in the interview were defined for computer simulation. The cumulative folder appraisal program was written for the Philco 2000 computer.

The automated cumulative folder appraisal system accepts as inputs the data in the cumulative folder--grades, aptitude test scores, parents' occupation, etc. The program analyzes these data, applying the programmed "rules" abstracted from the counselor's verbal behavior, and selects output statements such as the following:

Appendix H (cont)

"Student's grades have gone down quite a bit. Ask about this in interview. Possibly there are personal problems."

"Student should be watched closely. He will probably need remedial courses."

"Student is a potential dropout."

"Low counseling priority. No problems apparent."

(Reference 14 contains the logical flow chart used for the automated cumulative record appraisal program.)

In the automated interview, the student-program interaction takes place through the medium of a teletypewriter connected to a Q-32 computer.

The interview goes through the following procedures. (Attachment 1 to this appendix contains the actual printout of an interview that was conducted during the evaluation study described below.) First, using conventional computer-based programmed instruction techniques, the student is given a five-minute lesson on use of the teletype. Next, the student's cumulative folder record is inspected and the machine types out the student's courses and grades for the last semester and asks the student to indicate courses in which he is still having problems. If the student specifies problem courses, the machine asks him to type in his own words, a description of the problem for each course. These descriptions are stored on magnetic tape and later are printed out on an off-line printer. The printouts are sent to the counselor.

Following the description of problems, the machine asks the student if he would like to stop the interview to go see his counselor or if he would like to continue. If the student continues, his goals are explored next. The machine asks if the student plans to go to college. If he does, the program assists him in selecting the type of college he hopes to attend. If he does not, the student and the computer explore vocational alternatives in order to establish the student's vocational interests.

Following the selection of college or vocation, the machine assists the student in determining his major field of interest. The student is then given a statement regarding the probable grades that he will make in high school and a statement about his chance of success in his chosen posthigh school activity. These predictions are based on statistics accumulated by the Palo Alto School System.

Appendix H (cont)

Then the machine requests that the student select courses for 10th, 11th, and 12th grades. The machine evaluates the student's choices and advises him regarding required courses, appropriate course loads, and the relevance of his electives to his chosen major.

Throughout the interview, records are kept by the program, and when certain critical events occur, messages are composed. At the conclusion of the interview, all such messages are printed out for transmittal to a counselor.

B. EVALUATION OF THE AUTOMATED PROCEDURES

An investigation was conducted between March 22 and March 26, 1965, to assess the simulation and to appraise student acceptance of the automated interview (References 14, 22). Forty ninth-grade students were randomly selected from the population of ninth-grade students at the Wilbur Junior High School in Palo Alto, California. The students' total Scholastic and College Aptitude Test (SCAT) scores ranged from the third percentile to the ninety-sixth percentile. The group is somewhat above the national average in aptitude.

A teletype was installed at the school and was connected by telephone line to the Q-32 computer at SDC in Santa Monica. All 40 students took the automated interview. In addition, all of the data in the cumulative folders of the 40 students were analyzed by the appraisal program. Twenty of the 40 students were also interviewed by the original counselor; the other 20 were interviewed by a second counselor. The second counselor was included in the study to provide some estimate of the generality of the model.

To control the effects of sequence and order, each group of 20 was further divided into two subgroups of ten. One group of ten students went to the computer first for the interview and then went to the counselor. The other group of ten saw the counselor first and then was interviewed by the computer.

Following each interview, either by human or machine, the students were given an opinion questionnaire designed to measure their attitudes toward the interview. When each student had completed both the human and the machine interviews, he was given a standardized interview (Reference 22) to obtain more detailed information on his attitudes toward the machine and human interviews.

The results of the study are summarized in four broad categories: (1) those areas in which there appeared to be no marked difference between the counselor and the automated systems; (2) those areas where differences were observed between the automated systems and the counselor; (3) findings about the reaction of students to the automated procedure; and (4) areas that require further study.

Appendix H (cont)

1. Areas of No Difference Between Automated Systems and Counselor

No significant differences were found between the appraisal behavior of the two counselors and the computer appraisal programs on three-fourths of the appraisal statements. Both the human counselor and the computer performed similarly in identifying the following: changes in the pattern of student's grades; underachievement; overambitious plans; need for remedial work; appropriate and inappropriate posthigh school plans.

2. Areas of Difference Between Automated Systems and the Counselor

The automated appraisal programs identified significantly more students as overachievers and more students as potential dropouts than did either of the two counselors. Both of these differences were clearly attributable to the fact that the computer program was generally more pessimistic in predicting the future achievement of students in the lower aptitude levels. A change of the computer program to modify this one function would produce a much greater similarity between the counselors and the automated procedures.

The schedules made by the students under the automated conditions tended to differ from the schedules made with the counselor present. This was true not only for the specific courses which were selected but also in the number of course schedules that were completed. In this latter sense, the computer was more permissive than the counselors. It neither compelled the student to make a complete program of courses nor to make any attempt at preparation of a program.

The results were affected by the order in which the interviews occurred. When the machine interview was administered first, there were greater differences between the schedule produced with the machine and the schedule produced with the counselor than occurred when the counselor interview was first. This observation led us to conclude that the counselor exerted more influence on the students than did the machine interview program.

Also, a significantly larger number of students expressed concern over problems to both counselor and machine when the machine interview occurred first in the sequence. This difference may be attributed to the fact that the computer interview always asked students if they had problems, while the counselors may not have asked. In addition, some students stated emphatically that they felt the confidentiality of the machine interview was a strong point in its favor.

Appendix H (cont)

3. Reaction of Students to the Automated Procedure

One set of attitude questions were presented following the automated interview; another set was used following the human counseling interview. The questionnaire items were tailored to the two different situations. The scoring was such that if one-half the items on each scale was answered negatively and one-half positively, the total score would be 90 on each of the two scales. The actual mean score for the students on the post-machine interview scale was 105, and the actual mean score for the students on the post-human counselor scale was 119. These mean scores indicate a tendency for the attitudes of the students to be in the positive direction. There were wide individual differences among students in each group. A few students seemed to react very positively to the machine and a few expressed a strong preference for the counselor.

In the standardized interview after both the automated interview evaluation and the human counseling interview, 53% of the students indicated that the machine was not able to take into consideration all of the data necessary to make adequate plans for high school. Most of these students felt the machine did not give enough consideration to personal interests and personality variables. Fifty-six percent of the students expressed some reservation about course plans made with computer assistance, whereas only 20% had reservations about course plans made with the counselor.

Six percent of the students reported that the computer interview bored them and made them restless; 26% of the students felt bothered by the fact that the computer did not give them any reassurance as to whether or not their choices were appropriate.

Only one of the 40 students in the study chose to terminate the machine interview before making plans for his 10th year in school.

4. Problems for Future Study

The results of the pilot study indicate that simulation of logical appraisal procedures is more easily achieved than automation of complex interviewing procedures. Further study of the appraisal process should consider how the counselor's appraisal decisions based on the quantitative data are modified by the interview.

One of the counselors in the pilot study was from the Wilbur Junior High School in which the study was conducted. The other counselor (the original counselor) was from another school. Of the total number of appraisal statements made by the counselor who knew the students (97 statements), 42% (41 statements) were also made by the computer model. Of the total number of appraisal statements

Appendix H (cont)

made by the original counselor (53), 77% (41 statements) were also made by the computer model. This result indicates that the computer model represents the original counselor who was simulated better than the counselor who knew the students. However, the difference may also be attributed to the fact that the counselor from Wilbur Junior High School used additional data obtained from first-hand knowledge of the students.

The automation of interview functions needs further study. The study indicates that more than one cycle is required in the analysis and design process to achieve accurate simulation. Most of the differences in the output of the human and the machine interviews could be resolved by modifying the program and conducting a few cycles of system tests with additional samples of students. However, the problem involves more than accurate simulation or reduction in differences. The data on student reaction suggest that there are individual differences among students in their response to the automated system. The data also suggest that there are sequence effects that should be considered. In some cases, a period of time spent working with the machine may make the student more productive in the interview with the counselor. In other cases, the contrast between the machine and the human could make the student develop a strong desire for human contact that would make him more dependent upon the human.

Further study of whether the machine interview is better or worse than the human counselor does not seem to be advisable. The question to be answered is "How and to what extent can automated interviewing be successfully integrated into the counseling process?" The pilot studies indicate that automated interviewing procedures can be developed. Adequate field study will be required so that we can have some basis for recommending how procedures such as automated appraisal and automated interviewing can be used in actual counseling practice.

A proposal requesting support to carry this phase of the work further was submitted to the Division of Adult and Vocational Research of the USOE on June 1, 1965. The proposal (No. HRD-405-65) was approved August 16, 1965 and contract (No. OE-6-85-076) authorization was received on December 3, 1965. Initial work on this project is now in progress.

APPENDIX H,

ATTACHMENT 1

SAMPLE INTERVIEW

Appendix H, Attachment 1

YOU ARE ABOUT TO PARTICIPATE IN AN INTERVIEW WITH AN
AUTOMATED COUNSELOR.
THE COMPUTER WILL HELP YOU PLAN WHAT YOU WANT
TO DO IN HIGH SCHOOL AND IN LATER LIFE.
BUT FIRST, JUST TO LET THE COMPUTER KNOW YOU ARE THERE
PLEASE TYPE THE LETTER A AND A CARRIAGE RETURN
(RED KEY ON THE RIGHT-HAND SIDE OF THE KEYBOARD).

**** A
GOOD...
THE MOST IMPORTANT KEY IS THE CR KEY (RED KEY ON THE RIGHT).
YOU WILL USE IT TO LET THE COMPUTER KNOW THAT YOU HAVE MADE
AN ANSWER. JUST FOR PRACTICE, TYPE THE LETTER B AND CR (RED KEY).

**** B
OK.....
SOMETIMES YOU WILL BE ASKED TO ANSWER A YES OR NO QUESTION.
WHEN YOU ARE, JUST TYPE YES OR NO AND A CR
DON'T FORGET THE CR.
LET'S TRY IT. HERE IS A QUESTION---
ARE YOU IN CALIFORNIA NOW?
PLEASE TYPE YES OR NO.

**** YES
FINE..

MANY OTHER PEOPLE ARE USING THIS COMPUTER RIGHT NOW.
ONCE IN A WHILE THE COMPUTER WILL HAVE TO TAKE CARE OF THEIR
URGENT NEEDS. WHEN THIS HAPPENS, YOU MAY FIND THAT YOU
HAVE TO WAIT A MOMENT OR TWO. DON'T WORRY, THE COMPUTER WILL
COME BACK TO TAKE CARE OF YOU AS SOON AS IT CAN.
WHEN YOU HAVE READ THIS, TYPE OK AND CR.

**** OK
GOOD.
BY NOW YOU HAVE NOTICED THAT BEFORE YOU TYPE AN ANSWER,
THE TYPEWRITER TYPES STARS LIKE THIS-

****
THIS IS TO LET YOU KNOW THAT IT IS TIME FOR YOU TO TYPE
SOMETHING. YOU SHOULD NEVER TYPE ANYTHING UNTIL AFTER THE STARS
ARE TYPED OUT BY THE COMPUTER.
DO YOU UNDERSTAND?
PLEASE TYPE YES OR NO.

Appendix H, Attachment 1 (cont)

**** YES
ANOTHER VERY IMPORTANT KEY IS THE / OR ''SLASH'' KEY.
IT IS THE GREEN KEY ON THE BOTTOM RIGHT OF THE KEYBOARD.
LOOK FOR THE / KEY (GREEN KEY). WHEN YOU FIND IT,
TYPE / AND CR.

**** /
SOMETIMES YOU WILL HAVE TO TYPE MORE THAN ONE LINE AND THE
COMPUTER CANNOT TELL IN ADVANCE HOW MANY LINES YOU WILL TYPE.
IN SUCH A CASE, YOU WILL LET THE COMPUTER KNOW THAT YOU HAVE
FINISHED BY TYPING / AND CR.
WHAT YOU TYPE WILL LOOK SOMETHING LIKE THIS---

**** 1

**** 2

**** /

LET'S TRY IT.
TYPE 1 AND CR, 2 AND CR, AND / AND CR.
(WAIT FOR THE STARS.)

**** 1

**** 2

**** /
FINE..

PLEASE TYPE YOUR ID NUMBER AND A CR

**** 42
ONE MOMENT, PLEASE.

IS YOUR NAME DEBORA ANDERSON

**** YES
ACCORDING TO MY RECORDS THIS IS HOW YOU DID LAST SEMESTER.

CODE	COURSE	GRADE
1	P.E.	A
2	ENGLISH 1	A
3	GENERAL SCIENCE	A
4	EUROPEAN HISTORY	C
5	ALGEBRA	B
6	SCHOOL SERVICE	A

Appendix H, Attachment 1 (cont)

IS THIS CORRECT? IF SO, TYPE YES IF NOT, TYPE NO

**** YES
ARE YOU HAVING ANY PROBLEMS WITH ANY OF THESE COURSES?
PLEASE TYPE YES OR NO.

**** YES
TYPE THE NUMBER OF EACH COURSE THAT IS GIVING YOU TROUBLE.
TYPE CR AFTER EACH NUMBER.
WHEN YOU ARE ALL THROUGH, TYPE / AND CR.

**** 4

**** /
WHAT KIND OF PROBLEM DO YOU HAVE WITH EUROPEAN HISTORY
PLEASE TYPE IN THE NATURE OF THE PROBLEM. A FEW WORDS WILL BE O.K.
WHEN YOU ARE ALL FINISHED, TYPE / AND CR.

**** I DON'T TURN MY WORK IN ON TIME./
I SEE...
IF YOU WOULD LIKE TO DISCUSS THIS PROBLEM FURTHER,
MAKE AN APPOINTMENT TO SEE YOUR COUNSELOR.

WOULD YOU LIKE TO CONTINUE WITH THIS INTERVIEW AT THIS TIME, OR WOULD
YOU LIKE TO DISCUSS YOUR PROBLEMS WITH YOUR COUNSELOR BEFORE YOU CONTINUE?
TYPE GO IF YOU'D LIKE TO CONTINUE. TYPE STOP IF YOU'D LIKE TO STOP.

**** GO
DO YOU PLAN TO CONTINUE YOUR FORMAL EDUCATION BEYOND HIGH SCHOOL?

**** YES
WHICH OF THE FOLLOWING IS MOST LIKE THE SCHOOL YOU PLAN TO ATTEND?
1 IVY LEAGUE COLLEGE
2 OTHER COLLEGE OR UNIVERSITY
3 CALIFORNIA STATE COLLEGE
4 JUNIOR COLLEGE
5 BUSINESS OR VOCATIONAL SCHOOL
6 I HAVE NOT YET DECIDED
TYPE THE APPROPRIATE CODE.

**** 3
DO YOU INTEND TO MAJOR IN ENGINEERING OR ONE OF THE SCIENCES?
PLEASE TYPE YES OR NO.

**** YES

Appendix H, Attachment 1 (cont)

HERE ARE SOME AREAS OF SCIENCE AND SOME EXAMPLES

CODE	AREA	EXAMPLES
1	PHYSICAL SCIENCES.....	PHYSICS, CHEMISTRY, GEOLOGY, ETC.
2	BIOLOGICAL SCIENCES...	BIOLOGY, PRE-MED, PRE-NURSING, ETC.
3	SOCIAL SCIENCES.......	PSYCHOLOGY, SOCIOLOGY, ANTHROPOLOGY, ETC.
4	MATHEMATICS...........	MATH, STATISTICS, COMPUTER PROGRAMMING, ETC.
5	ENGINEERING...........	ARCHITECTURE, DRAFTING, ELECTRONICS, ETC.

PLEASE TYPE THE CODE NUMBER OF THE KIND OF SCIENCE YOU INTEND
TO MAJOR IN.

**** 3
ALRIGHT. LET'S SEE IF WE CAN PINPOINT YOUR AREA

1 PSYCHOLOGY
2 SOCIOLOGY
3 ANTHROPOLOGY
4 SOCIAL WORK

TYPE THE APPROPRIATE CODE.

**** 1
OK.....
THE GRADES YOU GET IN HIGH SCHOOL LARGELY DETERMINE THE TYPE OF
COLLEGE YOU WILL BE ABLE TO ATTEND.
LET'S JUST TAKE A LOOK AT YOUR PROJECTED HIGH SCHOOL GRADES
BASED ON YOUR PRESENT PERFORMANCE.
STUDENTS WHO GOT GRADES LIKE YOURS IN JUNIOR HIGH,
DID AS FOLLOWS AT CUBBERLEY---

70 PER CENT EARNED A OR B
20 PER CENT EARNED C+
10 PER CENT EARNED C

ON THE BASIS OF YOUR PROJECTED GRADES, YOUR PRESENT COLLEGE CHOICE
INDICATES THAT YOU ARE THINKING PRETTY REALISTICALLY ABOUT YOUR
FUTURE LIFE.

NOW THAT WE'VE GOT SOME IDEA OF WHAT YOU'D LIKE TO DO
AFTER HIGH SCHOOL, LET'S LOOK AT YOUR HIGH SCHOOL COURSE PLANS.
IN THE 10TH GRADE, THE REQUIRED COURSES ARE---

ENGLISH 2
CONTEMPORARY WORLD HISTORY AND GEOGRAPHY
PHYSICAL EDUCATION

Appendix H, Attachment 1 (cont)

WHAT OTHER COURSES WOULD YOU LIKE TO TAKE NEXT YEAR?
LOOK AT THE LIST OF COURSES.
WHEN YOU HAVE DECIDED WHAT COURSES YOU WANT TO TAKE, TYPE YES.
IF YOU CAN'T MAKE UP YOUR MIND AT ALL TYPE NO

**** YES
GOOD.
TYPE THE CODE NUMBER OF EACH COURSE YOU WANT TO TAKE.
TYPE CR AFTER EACH NUMBER.
WHEN YOU ARE ALL THROUGH, TYPE / AND CR.

**** 70

**** 93

**** 111

**** /
OK, HERE IS THE PROGRAM YOU HAVE PROPOSED

ENGLISH 2
CONTEMPORARY WORLD HISTORY AND GEOGRAPHY
PHYSICAL EDUCATION

FRENCH 1
MATH M 1
BIOLOGY 1

ARE YOU SATISFIED WITH THIS PROGRAM?
IF SO, TYPE YES
IF YOU WOULD LIKE TO CHANGE IT, TYPE CHANGE

**** YES
OK.....
THAT LOOKS LIKE A PRETTY GOOD 10TH GRADE PROGRAM.
DO YOU ANTICIPATE TAKING ANY SUMMER COURSES THAT YEAR?

**** NO
OK.....
AT THE 9TH GRADE YOUR PROJECTED 11TH AND 12TH GRADE SCHEDULE IS
CONSIDERED TO BE TENTATIVE. FIRM DECISIONS CAN BE MADE
ONLY ON THE BASIS OF YOUR YEAR BY YEAR PERFORMANCE.
WHAT YOU DECIDE TO TAKE IN THE 11TH AND 12TH GRADES
WILL BE GOVERNED LARGELY BY WHAT IT IS YOU WANT TO DO AFTER

Appendix H, Attachment 1 (cont)

HIGH SCHOOL. SINCE A PERSON'S PLANS TEND TO CHANGE OVER A PERIOD OF TIME, YOU SHOULD SEE YOUR COUNSELOR TOWARD THE END OF YOUR 10TH YEAR IN ORDER TO EVALUATE YOUR 11TH AND 12TH GRADE PROGRAM IN THE LIGHT OF YOUR CURRENT GOALS.

ALTHOUGH WE WILL BE TALKING ABOUT TENTATIVE PLANS, WHICH YOU WILL BE ABLE TO CHANGE, LET'S LOOK AT YOUR HIGH SCHOOL COURSE PLANS AS YOU SEE THEM NOW.

LET'S THINK ABOUT THE 11TH GRADE.

THE REQUIRED COURSES FOR THE 11TH GRADE ARE---

ENGLISH 3
U.S. HISTORY
P.E.

WHAT OTHER COURSES WOULD YOU LIKE TO TAKE IN THE 11TH GRADE?
LOOK AT THE LIST OF COURSES.
WHEN YOU HAVE DECIDED WHAT COURSES YOU WANT TO TAKE, TYPE YES.
IF YOU CAN'T MAKE UP YOUR MIND AT ALL TYPE NO

**** YES
GOOD.
TYPE THE CODE NUMBER OF EACH COURSE YOU WANT TO TAKE.
TYPE CR AFTER EACH NUMBER.
WHEN YOU ARE ALL THROUGH, TYPE / AND CR.

**** 71

**** 96

**** 43

**** /
OK, HERE IS THE PROGRAM YOU HAVE PROPOSED

ENGLISH 3
U.S. HISTORY
P.E.

FRENCH 2
MATH M 25
CREATIVE WRITING 1

Appendix H, Attachment 1 (cont)

ARE YOU SATISFIED WITH THIS PROGRAM?
IS SO, TYPE YES
IF YOU WOULD LIKE TO CHANGE IT, TYPE CHANGE

**** YES
OK.....
THAT LOOKS LIKE A REASONABLE 11TH GRADE PROGRAM.
DO YOU ANTICIPATE TAKING ANY SUMMER COURSES THAT YEAR?

**** YES
GOOD. TYPE THE CODES OF THOSE COURSES YOU WILL TAKE IN THE SUMMER.
TYPE CR AFTER EACH NUMBER.
WHEN YOU ARE ALL THROUGH, TYPE / AND CR.

**** 130

**** /
ALRIGHT. THAT MEANS THAT IN SUMMER SCHOOL YOU WILL TAKE---

DRIVER EDUCATION
NOW LET'S THINK ABOUT THE 12TH GRADE.
THE REQUIRED COURSES FOR THE 12TH GRADE ARE---

GOVERNMENT 2
PHYSICAL EDUCATION

(ENGLISH 4 IS NOT REQUIRED, BUT YOU MAY WANT TO TAKE IT.)

WHAT OTHER COURSES WOULD YOU LIKE TO TAKE IN THE 12TH GRADE?
LOOK AT THE LIST OF COURSES.
WHEN YOU HAVE DECIDED WHAT COURSES YOU WANT TO TAKE, TYPE YES.
IF YOU CAN'T MAKE UP YOUR MIND AT ALL TYPE NO

**** YES
GOOD.
TYPE THE CODE NUMBER OF EACH COURSE YOU WANT TO TAKE.
TYPE CR AFTER EACH NUMBER.
WHEN YOU ARE ALL THROUGH, TYPE / AND CR.

**** 72

**** 64

**** /
OK, HERE IS THE PROGRAM YOU HAVE PROPOSED

Appendix H, Attachment 1 (cont)

GOVERNMENT 2
PHYSICAL EDUCATION

FRENCH 3
GIRL'S WOODWORK S

ARE YOU SATISFIED WITH THIS PROGRAM?
IF SO, TYPE YES
IF YOU WOULD LIKE TO CHANGE IT, TYPE CHANGE

**** YES
OK.....
THAT'S A PRETTY GOOD 12TH GRADE PROGRAM.
DO YOU ANTICIPATE TAKING ANY SUMMER COURSES THAT YEAR?

**** NO
IT IS A GOOD IDEA FOR ALL COLLEGE BOUND STUDENTS TO TAKE 4 YEARS
OF ENGLISH. GIVE THIS SOME THOUGHT.

I HOPE THIS INTERVIEW HAS PROVIDED YOU WITH SOME INFORMATION
TO THINK ABOUT IN PLANNING YOUR HIGH SCHOOL PROGRAM.
IT'S BEEN NICE INTERACTING WITH YOU.
THANK YOU, DEBBIE
THIS IS THE END OF THE INTERVIEW