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A GENERAL DESCRIPTION WAS PRESENTED OF THE SCHOOL SIMULATION PROJECT WHICH USED SYSTEMS ANALYSIS AND COMPUTER-SIMULATION TECHNIQUES FOR STUDYING ORGANIZATIONAL CHANGES IN EDUCATION. THE ORGANIZATIONAL MODIFICATIONS STUDIED WERE APPLICABLE TO THE IMPLEMENTATION OF INSTRUCTIONAL INNOVATIONS. FIVE HIGH SCHOOLS, VARYING IN THE EXTENT THEY WERE INNOVATIVE, WERE SELECTED FOR ANALYSIS. A COMPUTER-BASED SIMULATION VEHICLE WAS PLANNED FOR SERVING AS A CONCEPTUAL TOOL IN THE GENERATION OF RESEARCH HYPOTHESES ON WAYS IN WHICH SCHOOL DESIGN AND ORGANIZATION COULD BE IMPROVED. WITHIN THE STRATEGY OF THE PROJECT, SEVEN TENETS WERE LISTED AND DISCUSSED. FLOWCHARTS OF STUDY PROCEDURES AND OF INTERACTION AMONG THESE PROCEDURES WERE INCLUDED. (RS)

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ABSTRACT

This document defines the purpose and strategy of the School Simulation Project. This project aims to use analysis and simulation of school organization to investigate organizational modifications in education that will help implement instructional innovations. Five high schools varying in the extent to which they are innovating are being selected for analysis. In addition, a computer-based simulation vehicle will be constructed that will serve as a conceptual tool for generating research hypotheses about ways in which school design and organization can be improved, and for provisionally testing the implications of these hypotheses. Seven tenets, developed in the course of defining the study, are listed and discussed. The flow of study procedures and the interactions between these procedures are illustrated and discussed.

PURPOSE AND STRATEGY OF THE SCHOOL SIMULATION PROJECT

During the past 20 years great strides have been made in the development of educational methodology and technology. Unfortunately, despite obvious weakness in its ability to accommodate to instructional innovations, the formal organization or structure of education has remained relatively constant.

A major reason for the lack of change is the extreme complexity of designing school organizations that efficiently accommodate modern instructional innovations. An innovation such as programmed learning, for example, if used on a large scale in a school, has implications for the design and organization of the whole school. By providing a means for effective self study, it may allow students to progress at their own rates. It provides a means and even suggests the need for breaking away from the lock-step system of advancing students once a year only. However, when the spatial arrangements, the student scheduling problems, and the versatile and effective use of resources, such as teachers, are considered for an accommodating organizational plan, the problem of design is overwhelming. Man, without the aid of machines, has limited capacities for processing information. He is virtually unable to define and keep in mind the many variations in the hypothetical school he may be considering and at the same time calculate predictions of the permutations that might occur throughout the system when he uses an innovation such as programmed learning on a large scale.

At man's present level of capability for designing school organizations, he must formulate a relatively simple plan, try it in a real school, observe the problems as they arise, and attempt solutions on a piecemeal basis. It is in this costly fashion that schools have been designed in the past, and it is the pattern that must be followed in the future unless new solutions can be found.

A procedure that has shown promise for thinking through complex problems in the design of military and business systems is simulation. By building a representational model of the system, problems and solutions can be tried before the proposed system is actually designed. In this form of simulation the modeling is accomplished by programming the computer to store all the rules or procedures used to process students through the school. Ideally, the program contains all the procedures relevant to real instruction. It includes listings of all the resources used by the school in accomplishing its task and the rules that pertain to the use of the resources. Finally, it provides for the study and analysis of different school designs by simulating the operations of the various schools and by predicting the changes that would take place in students and resources as students progress through the school curriculum.

This paper defines the purpose and strategy of a project which uses analysis and simulation of school organization to investigate organizational modifications in education that will help implement instructional innovations.

PURPOSE OF THE STUDY

The research is designed to analyze and simulate existing or possible school organizations so that it will be possible to:

A. Define new roles for school personnel

In a traditional school, instructional and administrative-supervisory personnel have relatively well-defined roles. Advocates of many educational innovations and technological changes state that such innovations will "free the teacher for other activities." Critics suggest that the new roles have not been adequately defined. An objective of this research will be to define essential roles for various personnel in schools applying different types and configurations of educational media and other major innovations.

B. Provide information on the effects of new media

Critics of educational television and programmed learning have expressed opinions that if these techniques are applied extensively in a school, aside from any changes in the learning process, an unhealthful reduction in the amount and type of teacher-pupil and pupil-pupil interaction will result. A major objective of this research will be to investigate the extent to which such reservations concerning innovations are justified and to explore ways of adjusting for problems which become apparent.

C. Describe applications of data processing equipment

As flexibility is increased in school programs, student control problems increase, since regular and exact schedules will not be possible. Data processing equipment and procedures should find important application in such situations. One of the objectives of this study is to determine and describe ways in which such equipment might be used to facilitate student use of media adapted to individual instruction.

D. Provide information on amount and arrangement of school space

Traditional high schools are typically built with a number of similar classrooms to house students in groups that vary little in size. In addition, a few administrative offices, a gymnasium, a small library, and a limited number of additional rooms of varying sizes and purposes are provided. A school making wide use of new media might require the same total floor space but involve a quite different arrangement of that space. Semi-private stations for individual study, small seminar rooms, and large lecture rooms are all likely possibilities. An objective of this study is to provide information on amounts and probable uses and arrangements of floor space for schools adopting various new media.

E. Provide estimates of characteristics of graduating students

At the present time, most students are promoted annually from grade to grade, and almost all students complete high school in the age range 17-19. These graduating students are characterized by diverse achievements in the various curricular areas; this diversity is widely recognized. If major changes are made in schools, permitting students to proceed at self-determined rates through the use of auto-instructional devices, the characteristics of graduating student groups may change radically. Age of graduation may become much more variable. Also, if students are permitted to spend sufficient time to master each successive concept presented, a marked reduction in the actual range of achievement among graduates is possible. A fifth and very important objective of the project, then, is to provide information about possible changes in characteristics of graduating students as technological changes are introduced.

In addition, the purpose of the research is to attempt the construction of a computer-based simulation vehicle that will serve as a conceptual tool for generating challenging hypotheses for research, relating to ways in which school design and organization can be improved, and for provisionally testing the implications of hypotheses. Specifically, the plan is to use computer simulation techniques to build a vehicle that will provide:

1. The capability of building dynamic models of real or proposed high schools.

2. The capability of flexibly modifying the models to represent different design configurations.

3. Detailed output data that reflect the effects of various design changes within the model.

The simulation vehicle will be constructed so that any high school can be described in terms of school characteristics (resources, organizations, procedures, etc.) and student characteristics that bear on the school's instructional plan; for example:

a. The curriculum and its organization.

b. The spatial arrangement of the instructional space.

c. The resources such as programmed learning materials, teaching machines, equipment, teachers, counselors.

d. The procedures for scheduling students through the instructional system.

e. The procedures for scheduling students through the counseling system.

f. The procedures for admitting and terminating students.

g. The procedures for relating to external agencies directly concerned with helping students.

h. The information processing procedures.

i. The characteristics of the students that relate to the instructional and counseling process.

j. The decision-making procedures.

STRATEGY OF THE STUDY

The major purpose of the study is to find new solutions to implementing instructional media through analysis and simulation of school organization. However, in order to provide a realistic data base for the study, five high schools varying in their use of innovation will be selected for analysis. The problems of selecting the five schools, collecting descriptive data on each analyzing them, constructing a general simulation vehicle, generating hypotheses for research, and making recommendations for the design of schools requires an elaborate research strategy. In the following two sections, the general and the specific strategies of the project are discussed.

General Strategy

A number of tenets should be made explicit that have been developed in the process of defining the study.

1. Measures must be defined, and procedures for analysis and reduction of data must be developed to make the simulation vehicle useful as a conceptual tool. Simulation efforts in the past have tended to slight the importance of this point. This may be because the effort and thought that goes into constructing a detailed dynamic model is so great that the researchers are tempted to assume that the more explicit descriptive formulation that they achieve places them in a better position to decide how the environment which is being modeled can be improved. But description by itself--no matter how detailed and no matter how explicit--does not ensure an increase in the number of hypotheses about how things might be improved. At best, the descriptive model provides a formal statement in algorithmic form that can be useful for reference and communication purposes when thinking about how the environment can be improved. If such a statement is what is sought in the study, there is no need for computer simulation; descriptive flow

charts should be adequate for this purpose.

However, if the study is to provide a tool for generating research hypotheses about ways in which schools can be improved, and for provisionally testing the implications of these hypotheses, computer simulation is required. The computer simulation vehicle should provide a means for actually making modifications in the design. It should also provide data that may be of use in making judgments about the implications of the design changes. Without such a capability, the researcher is in a position similar to the investigator who makes changes within a real school before he has developed measures to help him evaluate the results. He must rely on reports from casual observation. But the investigators who are trying to evaluate an idea by means of computer simulation ce not query simulated teachers and treat them as casual observers.

2. The questions that are formulated about school organization at any point in time during the study operationally define the orientation of the project at that time and determine the variables that are selected for analysis, simulation, and measurement. The point of view expressed in this tenet is that the process of study is always directed toward solving particular problems. The process is not aimless and random. The major interest is not to construct dynamic models of schools and then to look for results that seem to have significance. On the contrary, the study is oriented toward the solution of problems. The best definition of this orientation is the questions about school organization that are raised in the process of the study. The questions will define the growth and shifts in orientation of the project.

The basic question underlying the study is "Can organizational configurations be developed that will help implement instructional innovations?" This question has been further defined by the five project objectives:

a. Can essential roles for personnel be defined in schools applying different types and configurations of educational media and other major innovations?

b. Can the effects of different educational media on teacher-pupil and pupil-pupil interaction be estimated? And, more specifically, can organizational plans be developed that increase the amount of interaction?

c. Can data processing techniques be designed for solving the problems associated with an individualized instructional process in schools? This question can be subdivided into a number of more specific questions, such as: Can resources be scheduled in such a way that students will be able to have instruction planned in an individualized manner? Can procedures be developed to keep track of student

progress? Can procedures be developed to determine when students are in trouble or need help? Can information retrieval techniques be developed that provide teachers a capability of getting an up-to-date and integrated picture of student progress?

d. What kinds of spatial arrangements are needed for adopting various new educational media and for various organizational plans?

e. What effects do different educational media and organizational plans have on students?

Each of these questions leads to more specific questions that relate more and more to specific educational media and organizational plans. Ultimately, the further refinement of the questions leads to the specification of the measures that will be used to evaluate the plans that are formulated and tested with the simulation vehicle. And the questions determine the variables that are included in the analysis and simulation. There is no point in simulating aspects of the school that have no relationship to the questions that are to be asked.

3. The results of computer simulation runs will present unanticipated patterns in the data that will form the basis for interesting hypotheses. In this sense, the simulation will create new ideas. Although the questions that are formulated will define the orientation of the study and will determine the measures that are developed, the computer simulation runs will produce data that suggest possible effects of innovation that would not be logically predicted. These effects may form the basis of hypotheses for empirical research.

4. The power of the simulation procedures for producing effective organizational plans depends ultimately upon the validity of the data and hypotheses that they produce. The design recommendations that emerge from the simulation runs must be considered hypotheses that are offered for empirical evaluation, rather than recommendations that have been adequately tested. The simulation model will tend to have the usual disadvantages of any model. It will tend to encourage overgeneralization and will entice users into a logical fallacy of the following simple conditional type: If the statement "if A then B" is true and if B is true, then this means that A is also true. The fallacy is obvious, yet it may trap a user of the model who, on finding that some function (B) of the model agrees with some function in real life (thus asserting the truth of B), concludes that the variables, constants, and assumed relationships (the A's) with which he began are valid. The confidence that is placed in the hypotheses or recommendations should depend upon the accumulation of empirical data that can be used to judge the validity of the recommendations.

Two kinds of validation studies should be conducted:

a. The recommendations suggested for school organization should be tried and evaluated in realistic school settings. The evaluation should cover a time period that will allow for an adequate evaluation. In other words, the time devoted to study should extend beyond the early period when initial enthusiasm from the novelty and increased public attention may elevate the findings.

b. The simulation runs will produce effects within the model that will be used to judge the effectiveness of various plans. For example, simulation runs may indicate that the experiences that students have in a continuous progress plan school will become more and more heterogeneous in a very short period of time, so that the problem of forming homogeneous groups and maintaining group continuity will be extremely difficult. More specific findings of this kind should be tested under empirical conditions to determine the correspondence between the operations that occur in the model and in the real situation.

5. A simulation vehicle constructed to provide the capability of modeling five high schools which vary markedly in the extent of educational innovation will have general applicability for modeling other high schools. The five schools that are analyzed in the project cannot be considered a representative sample of high schools in the United States. However, it is possible in future studies to obtain a simulation vehicle with wider applicability by selecting for simulation a more diverse and representative group of schools; for example, a traditional high school with little innovation, a school which uses the Continuous Progress Plan (Read, 1963) in which students progress at individual rates and spend much of their time in individual study, and a school which uses team teaching on a wide scale.

6. A facilitating reciprocal interaction exists between the task of collecting empirical data from the schools and the task of constructing the simulation vehicle. The project might be planned in such a way that the simulation vehicle would be constructed after the completion of the data collection. However, the formulation of a good simulation vehicle forces a more explicit and carefully thought-out consideration of the components in schools and of the interactions between these components. This greater consideration changes the data collection procedures by providing a more systematic basis for planning their collection. In addition, the collection of empirical data from the high schools affects the model building by directing greater attention to the details of the real environment. The project is planned so that both the data collection and the construction of the simulation vehicle occur simultaneously throughout a major part of the project's direction.

7. Mathematical modeling techniques will be explored for their applicability to specific problems, such as solving for the optimal number of counselors for a particular school organization. Simulation may provide a descriptive model that is expressed in algorithmic form. The explicit model, if constructed with a great deal of thought and careful consideration of reality, should be extremely useful for communicating and thinking about schools. But it does not provide any means for adequately solving analytic problems. Therefore, specific problems will be isolated for analysis, and mathematical modeling techniques will be explored for their applicability to these problems.

Specific Strategy of the Study

Figure 1 shows the flow of the major steps in the project. The steps proceed as follows:

1. The general knowledge of project personnel about the organization and structure of high schools at any given point in time is represented by block 1.

2. By transposing the general knowledge into a simulation model, the thinking that is usually unorganized and poorly formulated is explicated and systematically formalized.

3. The general knowledge and the more carefully formulated model determine the plans for the collection of data and the choice of data to be collected from the high schools that are selected for study.

4. Data which are descriptive of the schools are collected for analysis. Since the research emphasizes those aspects of the school most closely related to the instructional process, the information collected will include operating procedures of such areas as over-all organization, curriculum and instruction, and the counseling service.

   The top arrow from block 4 that leads into the arrow returning from block 9 shows that the collection of descriptive empirical data from the real schools feeds back into the general knowledge about high schools (block 1) and changes it. This change in the general knowledge will also lead to a change in the formulation of the simulation vehicle (block 2). In fact, the loop defined by blocks 1 through 4 will continue throughout the study. Both the growth and the generality of the simulation vehicle should increase as long as this process continues.

5. Analysis of the schools consists of constructing logical flow charts of the different phases showing operations, movement, decisions, and interactions.

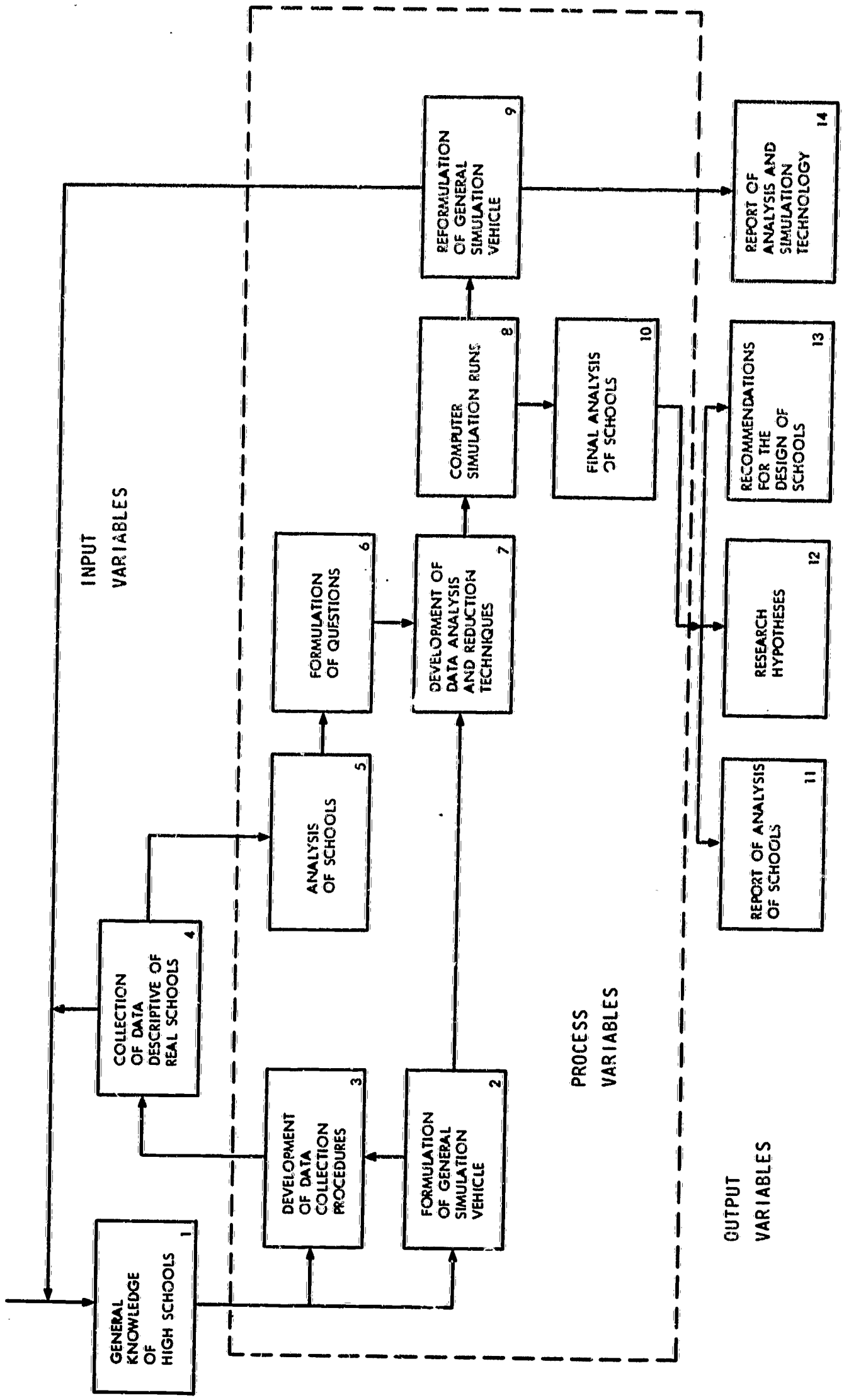

FIGURE 1. FLOW OF PROCEDURES IN THE SCHOOL SIMULATION PROJECT.

6. On the basis of the analysis, specific questions will be formulated about ways in which the schools can be improved. The word "questions" is used in this instance to distinguish it from the "hypotheses" referred to in block 12. The questions in block 6 might be thought of as hypotheses, because they will be ideas about how particular schools might be modified. The ideas will be tested with the simulation vehicle (block 8). However, testing design ideas with the simulation model does not constitute an empirical test. Therefore, the more formal term "hypotheses" is reserved for the ideas that withstand the simulation tests and are then offered for empirical test (block 12).

7. Criterion data or measurements that can be used to help answer the questions raised in block 6 will be developed. This is one of the most important steps in the study. The potential of formulating design improvements depends to a great extent upon the availability of measures that show the effects of design changes.

8. The various design modifications suggested by the analysis and the questions that have been formulated are simulated with the model on the computer.

9. It is assumed that actual computer runs with the simulation model will serve as a checkout of the procedures in the model and will probably show inadequacies in the model. Therefore, the general simulation model will be revised to incorporate changes suggested by the test runs. A feedback loop from block 9 to block 1 is shown to illustrate that the process of analysis and simulation leads to modifications in the general knowledge of high schools.

10. The results of the analysis described in block 5 and the results of the simulation runs are combined into final analyses or conclusions.

11. Blocks 11, 12, 13, and 14 show the major outputs that can be expected from the study. Block 11 represents the reports of the analyses of the five schools.

12. The simulation effort is oriented toward developing a general model of schools that will incorporate aspects general to all schools, but will permit the modeling of any specific school organization or proposed organization. To the extent that the model has generality it should serve the utility function of a theory by facilitating the generation of research hypotheses.

13. Since the main purpose of the study is to find new solutions to the implementation of instructional media through the analysis and simulation of school organizations, it is expected that recommendations regarding the design of schools will be formulated.

14. Finally, a technology for analyzing and formulating design changes in schools is expected.

The data collection and analysis of the five schools is represented by blocks 4, 5, 8, 10 and 11. A more representational portrayal would repeat the flow five times on a horizontal plane to illustrate that the procedures are repeated for each school. The more detailed description also would emphasize the fact that the model or simulation vehicle is continually reformulated and developed in relation to the study of the five schools.

The School Simulation Project should provide a more carefully developed, more systematically planned, and more explicit analysis of the problem of implementing innovation in education than has been heretofore accomplished. By giving greater consideration to the detailed analysis of school organization in its relationship to innovation, the study should produce design suggestions for schools, that are more dramatic in their implications for education.

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