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APPLYING OPERATIONAL ANALYSIS TO URBAN EDUCATIONAL SYSTEMS, A WORKING PAPER.

BY- SISSON, ROGER L.
PENNSYLVANIA UNIV., PHILADELPHIA, MANAGE. SCI. CTR

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OPERATIONS RESEARCH CONCEPTS ARE POTENTIALLY USEFUL FOR STUDY OF SUCH LARGE URBAN SCHOOL DISTRICT PROBLEMS AS INFORMATION FLOW, PHYSICAL STRUCTURE OF THE DISTRICT, ADMINISTRATIVE DECISION MAKING BOARD POLICY FUNCTIONS, AND THE BUDGET STRUCTURE. OPERATIONAL ANALYSIS REQUIRES (1) IDENTIFICATION OF THE SYSTEM UNDER STUDY, (2) IDENTIFICATION OF SUBSYSTEMS, PROCESSES, FLOWS, AND DECISIONS, (3) DEVELOPMENT OF A SIMULATION MODEL INCLUDING BEHAVIORAL AND PERFORMANCE SUBSYSTEMS, (4) VALIDATION OF THE MODEL, AND (5) USE OF THE MODEL TO EXPLORE SUCH SYSTEM CHARACTERISTICS AS MANAGEMENT CONTROL, ALLOCATION OF RESOURCES, AND DECISION FLOW. (HM)

APPLYING OPERATIONAL ANALYSIS TO URBAN EDUCATIONAL SYSTEMS

WHARTON SCHOOL OF FINANCE AND COMMERCE
UNIVERSITY OF PENNSYLVANIA, Philadelphia 19104

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A Working Paper

Roger L. Sisson
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Management Science Center
University of Pennsylvania

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There has been much discussion, in recent months, of the fact that systems analysis or operational analysis is an effective way to study complex systems. [9] If this is true, then we should certainly attempt to apply these techniques to one of the most vital, complex systems of our society, the urban school district. To give impetus to such analysis, we will, in this paper, review what is meant by operational analysis and explore the first steps that would be required to apply it to the study of urban school systems.

What Operational Analysis Can Do

Early prognostications of the value of a new technology tend to be over-optimistic, and so it might be wise to remind ourselves just what we can expect from any analytic tool. Tools of analysis, when completely effective, are methods of predicting what will happen if we take certain courses of action. Theories of physics tell us what will happen if we apply more than a critical amount of thrust to an object in the vertical direction -- that object will go into orbit. We need not choose the course of action studied. The analysis makes a prediction, it does not issue commands. In the case of human endeavors, we also would like to find the course of action that will be "best" for the public being served by the endeavor. In simple cases (such as inventory control), it is possible to find by analysis the "best" course of action. However, as we study more and more complex systems, we find that the selection of the optimum or best course of action becomes nearly impossible, even with the aid of mathematical tools.

Complex systems involve many difficulties which do not exist in the lower level studies. First, it is often very difficult, if not impossible, to identify a single goal or objective. Many groups are involved in complex human organizations and each group tends to have a different set of goals which cannot be reconciled exactly with those of others. Since there is no clear cut goal, it is difficult to define what "best" means. Furthermore, the complexity of the system usually means that no concise mathematical formulation of a model can be obtained. And if a mathematical model cannot be developed, then it is extremely difficult to develop techniques for finding the "best" solution, even if goals can be defined.

Thus, although operational analysis might be extremely useful in providing us with predictions of what can happen if a course of action is taken, it will not in general, tell us what the best course of action is. The ultimate decision will still be made by appropriate elected or appointed authorities. But having predictions in the form of quantitative estimates of what may happen is much better than the groping studies now made in support of decisions on educational programs.

The Nature of Operational Analysis

Operational analysis is the quantitative study of a system. The word "system" in itself has no particular meaning. Almost anything can be abstracted as a system, from the universe as a whole to an assemply of tinker toys. The system is that which a particular group has chosen to study.

An operational analysis effort involves several identifiable, but complex, steps. The first three steps involve: defining the boundaries of the system under study, denoting the major subsystems and the way in which they interact and from these efforts, identifying the important variables. Since the research group must define the system under study, the first step is to identify the boundaries of the system which will be studied; that is, to identify what processes and phenomena are to be within the system (and studied in detail), and what processes and phenomena will be considered to be outside the system. Analysts tend to choose rather wide boundaries at first and narrow them down as the understanding of the system evolves. In other words, the boundaries chosen at first may be changed as the analysis proceeds in order either to incorporate better understanding of the system or to focus on a critical subsystem. At any time in the analysis, however, some set of boundaries is defined.

If we take as our problem area an urban school district, the choice of boundaries is extremely difficult. For example, it is obvious that the group of people called taxpayers have a significant effect on the school district; they provide a large portion of its financial resources. On the other hand, we would not generally include the taxpayer as a part of the urban school district. For the purposes of the study we wish to outline below, however, let us broaden our scope so that we are, in effect, studying the educational system of a region. Therefore, we might legitimately include the taxpaying group as a source of funds, just as we might include the shareholders as a part of a corporate organization. Obviously the setting of boundaries to define a system as complex as a regional educational system requires care; if the system defined is too large analysis may be infeasible, if too small important phenomena may be excluded. Even geographic limits are difficult to define since, for example, teachers may be recruited from outside the region under study.

Assuming, however, that boundaries have been set, the next step is to identify the basic phenomena within the system. There are several types of phenomena which must be integrated as the analysis proceeds. One type includes the ongoing processes. In an urban school system, examples of these would be: teaching (of many different kinds), construction of buildings, hiring of teachers, training of staff, etc. The second type includes the key decisions that are made throughout the system, such as: allocation of basic resources, decisions about personnel (hiring, assignments), decisions about curriculum, decisions about the location of schools, etc. The third phenomena is flow. In a school system there are flows of people from grade to grade, from the region, etc. There are flows of money or financial resources, flows of information and flows of materials and supplies. Below we will discuss the operational method of studying a system which incorporates all three of these types of phenomena.

Use of a Model

In operational analysis, the major methodological concept is to develop a model which can be used to study the system. [1] After the subsystems, decisions and flows are identified, model development can begin. The function of a model is well known in the physical sciences and has led to many of the advances in these disciplines. A model is even more important in the study of a complex system, such as an urban school district, since it is extremely expensive and difficult to run experiments on the system itself. It is therefore important to understand the nature of a model.

A model is a simulation or an analog of the system under study. (We will, however, use the word "simulation" in a narrower sense subsequently). There are several kinds of models, the most obvious being a physical model. For example, a model of an aircraft in a wind tunnel is a physical representation of key aspects of the real aircraft. The model is used to determine aerodynamic characteristics and to predict how the real plane would perform under various circumstances of flight. Physical models are not particularly useful in systems where the flow of information is a major phenomena as it is, in a school system. A second class of model is the symbolic-mathematical model. [8] This is the form of model which has been so successful in physical sciences. In this form of model we represent the system under study by two types of symbols. The first represents the values of variables describing the parts of the system; the second represent the relationships between these parts. The first type of symbol represents quantities, which, at least in principle, can be measured. The second or operational symbols, correspond to real-world processes or interactions between parts of the system. In using the model for analysis these operational symbols define logical manipulations of the descriptive variables. In other words, the operational symbols tell how the variables should change as a function of each other.

The beauty of the symbolic model is that, in some cases, we can find a mathematical structure which will help us manipulate the symbols so as to

make predictions very efficiently. If such a mathematical structure can be found or developed, then, by the manipulation of the symbols, we can develop formulas which will allow us to predict what would occur under a wide variety of circumstances. In fact, the existence of a mathematical structure often lets us go further. It lets us find the "best" solution (providing we can define a measure of "goodness"). It also lets us explore how performance will change as we take courses of action other than the "best" one. Unfortunately, however, it is very unlikely that we can find a mathematical structure which will permit us to manipulate a symbolic model of a situation as complex as a school district. Mathematics, advanced as it is, has not developed techniques which permit the manipulation of the thousands of highly interacting variables required to model a school district.

There is a third kind of a model, usually called computer simulation, which is appropriate for complex socio-economic system studies. [5] The variables of the system are represented by numbers within the computer memory. The dynamic processes are represented by a flow chart and dynamically modelled by a computer program which determines how the variables will change as time proceeds. After defining the variables and the program or procedure for their change, we can actually execute the model on a computer. That is, the simulator can be run. The result of running the simulator is a prediction of what will happen under the circumstances built into the model. Other runs can be made to make predictions under other circumstances. Thus, to study an urban school district through operational analysis techniques, a computer simulation model would be developed.

To review the discussion thus far, the steps of the analysis are: defining the system boundaries; identifying the major processes, flows, and decisions; isolating the variables and relationships implied by these processes, and developing a computer simulation model which represents or models the sytem.

In the final step of analysis the simulation model is used to study how the system will behave as various courses of action are adopted. For example, we could study how the system would behave if we reduced the student-to-teacher ratio, if we provide extensive remedial courses (for example, in reading or mathematics), if we provide additional staff development, if we change the management organization of a school district, or for other kinds of action that could be taken.

Problems with Operational Analysis in the Context

There are two major difficulties in developing a simulation model which will be sufficiently representative of a real school district to be useful. The first problem is to obtain measures of performance based on the system goals. This problem of course does not result simply from an attempt to perform operational analysis. The management control of school districts and the allocation of resources to a school system relative to other municipal functions both suffer from the fact that we have no good way of measuring the performance of a school district. Certainly, if we are going to analyze the system in order to choose better courses of action, we have to know what "better" means. Below we will propose some solutions to the problem of developing performance measures for a school district, and it should be clear that this is a step vital to the success of any analysis.

The second problem is that the model must represent the behavior of groups of people. It is possible to develop computer simulations which represent at least some phases of behavior. However, it is difficult. It is even more difficult to prove that these models are valid; i.e., good representations. A school system model will, for example, have to represent the behavior of students as they are taught under diverse situations. It will have to represent the behavior of taxpayers in regard to their willingness to support schools and the behavior of industrial management in regard to the employment of persons of various skills. It will also have to represent the behavior of teachers under various conditions of pay, management and availability of support.

We will discuss below this question of modelling behavior. It is difficult but an important step, if we are to succeed with the operational analysis.

Some Considerations in Modelling Complex Systems

An important decision which the systems analyst has to make in developing a model is to determine the level of aggregation. In other words, he must determine to what level of detail he is going to represent the real world. He could on one hand represent every student and every teacher every hour of the day, and thereby model, at a very exhaustive level of detail, the teaching process and all of its implications. At the other extreme, we could represent the annual activities of a school district and summarize the teaching process, the construction process, etc., in aggregate terms summarizing what is accomplished over a year. The choice of level of detail depends upon the purposes of the model and may change as the analysis develops. The analyst may expand the detail in part of a model in order to get a better representation of the real process, or he may aggregate a detailed part, if he finds that the detail does not contribute to the understanding of the system. In the discussion below, we will suggest some choices as to level of detail based on a preliminary, intuitive feeling as to what makes the difference in the system.

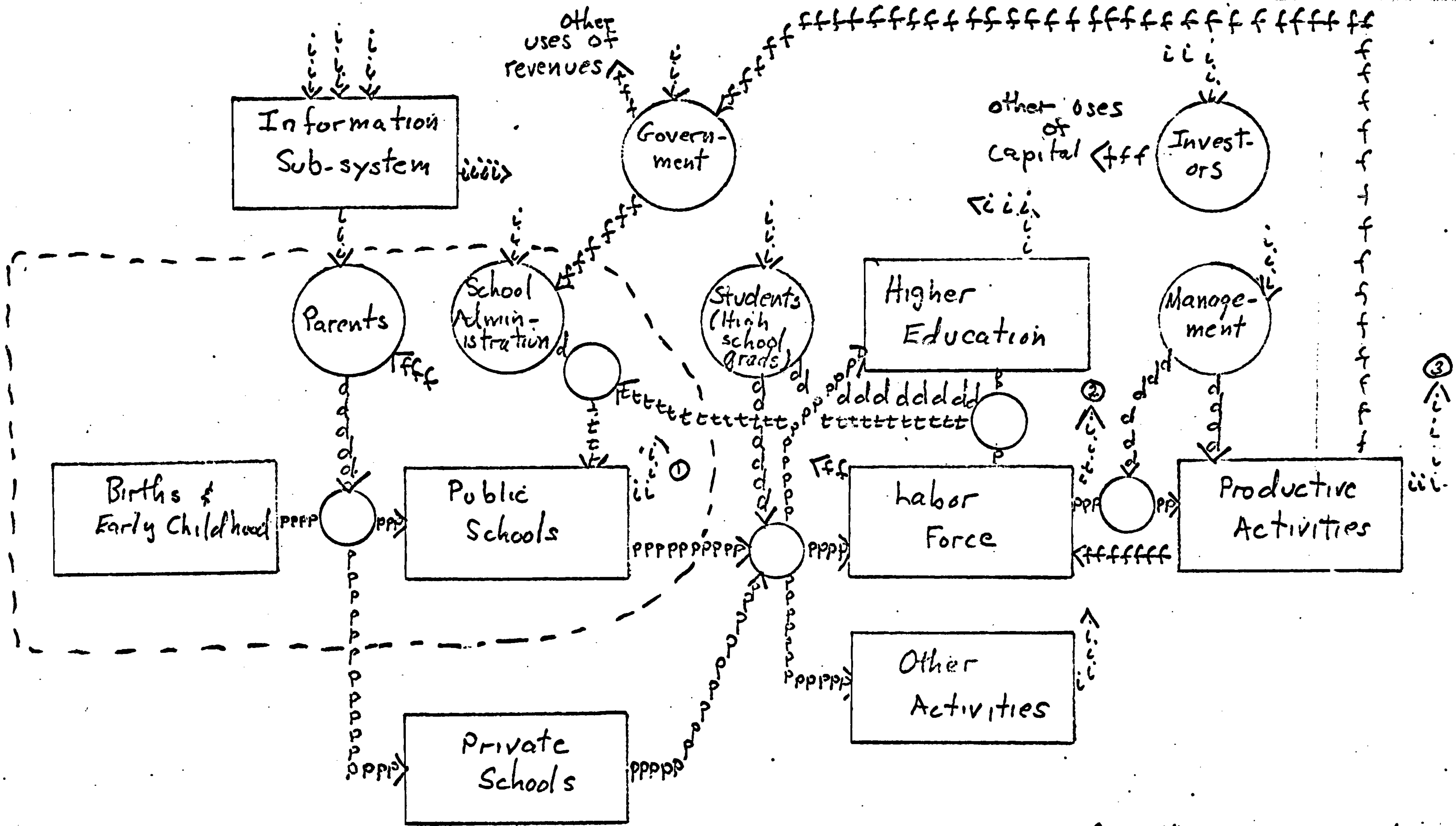
At whatever level of detail, the model usually can be developed in terms of terms of flows, processes, and decisions as we mentioned above. A process is an identifiable collection of activities which has inputs and outputs. The process is modelled by defining the outputs (at each interval of time to be represented) as a function of (that is, related to) the inputs at all previous times. For example, we can consider the teaching of first grade in a school district as a process. If we are working on a monthly basis, then we would want to represent the state of learning (however we may measure it) of the students at the end of each month as a function both of the resources which were applied during that month and the capabilities of the students at the beginning of the month. The inputs are the students with a certain level of learning and the resources (the teachers, the materials, the building, etc.). The output is the level of learning of the students at the end of the month. For every process in the system, we will need to develop these output-input relationships. The inputs and outputs can consist of several types of variables representing the different flows: people, information, materials, and financial resources. Consider a variable which numerically represents, for example, students' ability to read on some scale. This variable would be an output of the teaching process. Its value at the beginning of the month would be an input variable. The teaching hours applied to the student group might be another variable, in this case an input variable. Thus, we can say that the process is modelled when we can define the value of the output variables as a function of the values of the input variables at earlier times. In defining the system, we must also, of course, indicate which output variables from one process become the input variables to another process. The interconnection of variables in this manner represents the flows in the system.

Finally, there will be decision processes. Decision processes are processes like those we have just described; there will be output variables which are functions of input variables. The only difference is that the process represents the intellectual behavior of some decision maker and the output and input variables are always information variables (and not material or other flows).

A system model can thus be portrayed as a series of processes -- decision and operational -- interconnected by command variables. It is customary to represent each process by a box in a diagram and to show by arrows which output variables become input variables to other processes. Below, we will attempt to develop such diagrams for an urban school district.

An Aggregate Model of an Urban School District and Its Environment

Figure 1 is an effort to summarize by a diagram a system model, at a very aggregate level, of an urban public educational system.



① performance information
② unemployment levels
③ wages, job openings
} to information sub-system

Flows

p – people
t – teachers
i – information
d – decision control
f – financial resources

Regional Educational System

The level of aggregation varies, being more detailed for the educational sectors and less for other sectors of the total socio-economic environment. (The subsystem enclosed in a dashed line will be developed in more detail below).

In Figure 1, the "p" arrows show the flow of people through the system. The small circles are points where decisions affect flows. These are connected to larger circles which represent a decision process ("d" flow). For example, to the left of the diagram we show parents deciding whether to send children to public or private school. They base this decision on information which they obtain about schools and about opportunities for work and for higher education after school. They also base this decision on the financial support available. (Parents are generally also part of the labor force and thus have income, of course).

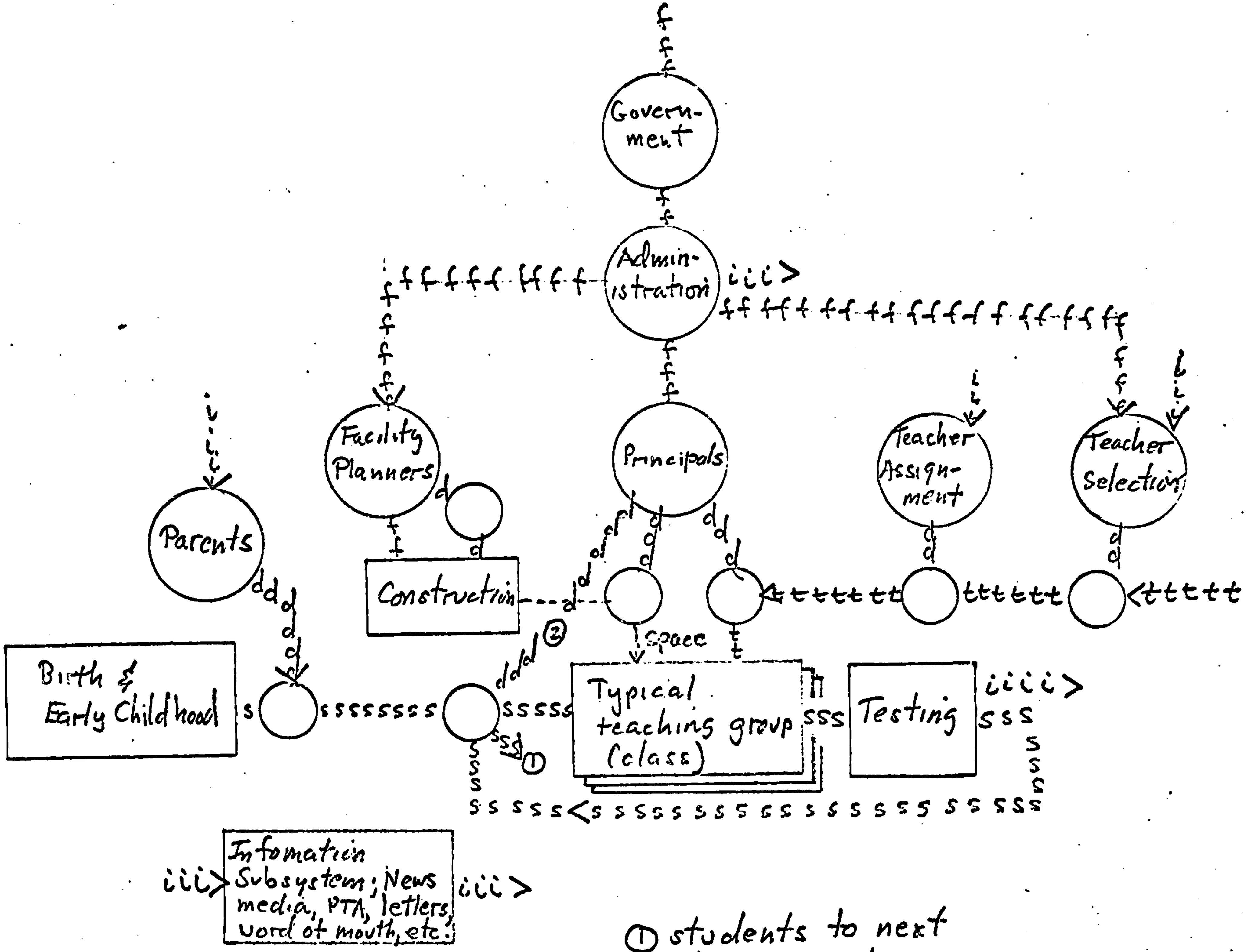
The "i" arrows show the flow of information from decision makers to the decision points. As another example, to the right of the diagram, industrial management controls the flow of people from the educational subsystems into job positions in the productive processes.

The "f" arrows show the flow of financial resources (money) throughout the system. In a sense, money is a form of information, but a special form in that it represents value in the socio-economic context. Note particularly the flow of money from the productive activity in the form of taxes through government agencies back to the school system. This, of course, is a summary for many complex flows of tax revenue received by Federal, State and Local governments and allocated to the schools.

In Figure 1 we have summarized the information subsystem as one process. Actually it would have to be studied in more detail to represent what information each decision maker receives and uses to make his decisions.

A Diagramatic Representation of the School District

Figure 2 summarizes a more detailed model of the school district itself; the subsystem in the dashed line in Figure 1. (Recall that the boxes represent computational models of processes and the arrows represent interconnections of variables which model flows). The similarity between the structure of the decision processes in Figure 2 and an organization's chart is not accidental. An organization chart is an effort to show how responsibility for making decisions is delegated. Here we have shown not only the flow of decisions but the flow of financial resources, (for example, in the form of budget allocations) the flow of students ("s") and teachers ("t") and also the flow of information ("i"). This subsystem might have to be detailed even further to obtain a good representation of a school district.



s- students
t- teachers
i- information (administrative information flows not detailed)
d- decisions
f- finances & budgets

① students to next class or grade

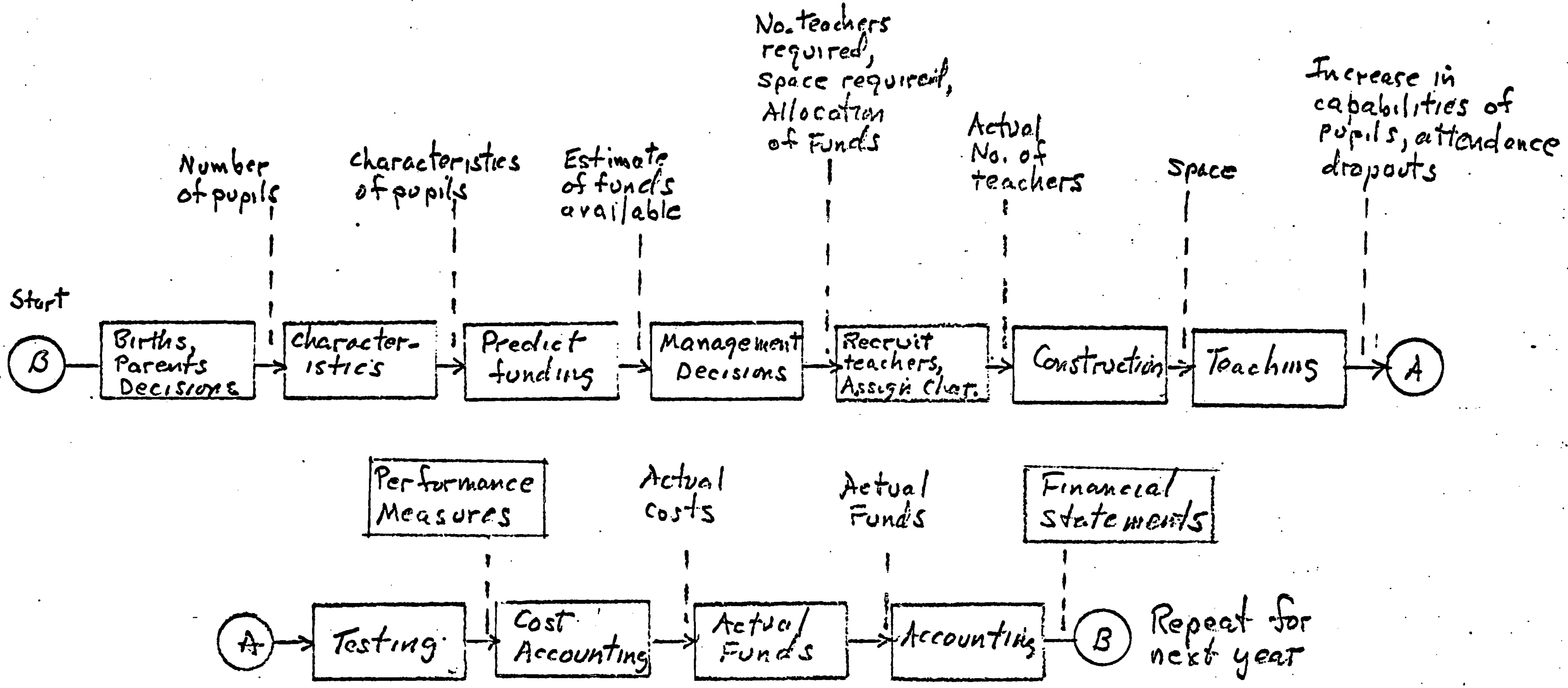
② decisions on student schedules

School District System (Partial)

Figure 2.

A Simulation Model

The diagrammatic model shown in Figure 2 is intended to convey the nature of the interactions assumed to be operative. It is not, however, a representation of a simulation. A simulation that represents the structure shown in Figure 2 can be developed. Recall that in a simulation model the key variables are represented by numerical quantities. Each of these numerical quantities will, of course, have a name which will identify it. Secondly, in a simulation model we have a procedure (which we will show as a flow chart) which describes how to manipulate the variables. Figure 3 is a flow chart for a model which represents an aggregated school district on a year by year basis. Some of the variables are named at the top of Figure 3 at the point in the simulation procedure where their values are calculated for the current (simulated) time period. The meaning of the boxes and the arrows in Figure 3 is somewhat different than in Figures 1 and 2. Here each box represents the sequence of arithmetic and logical steps which are to be carried out on the variables. These steps correspond to a model of the relationships supposed to exist in one of the processes of the system model and, hence, in the real situation. The arrows in the flow chart represent the sequence in which the computations are to take place. Since we are representing an entire year in one step, the sequence in which computations are made does not bear any particular



Simulation of School District

Figure 3.

relationship to the sequence in which things occur in the real world. It is the nature of computer simulation that they often represent sequentially processes that actually take place in parallel. This timing discrepancy does not invalidate the model. If the model is properly designed, useful studies can be made of long term phenomena. Studies of short term phenomena or of the detailed operation of the system would require simulations with a shorter basic time interval.

This model, as any model, must be oriented toward answering specific questions; it must have a purpose. A model which can answer any question about the system would be far too complex. The model similar to that summarized in Figure 3 has been developed at the University of Pennsylvania. [10] It is oriented toward answering those questions which arise in managing an entire school district; that is, toward studying the phenomena from the point of view of top management, the Board of Education and the Superintendent. For this reason, the model is quite aggregate and does not represent many of the detailed processes (which would be needed if we were to answer questions having to do with the operation at the level of the principal or the teacher). Also, the model is oriented toward answering questions about resource allocation rather than questions about personnel selection or system organization. These other questions are vital, of course, and the overall model based on Figure 2 will have to be developed to study organizational problems, which are so difficult in urban school systems and for studying other management decisions.

Consider Figure 3 again. It summarizes the various computations which have to be performed (in sequence) to represent Figure 2. First there is a process which represents the birth of people and their growth through to preschool age. A second part of this computation represents the parent decision to send their child to private or public school. Thus, the output of this computation is an estimate of a number of pupils of various ages to be educated in a public school system of the region.

The next computation determines the characteristics of these pupils. (In real life, of course, the characteristics would develop at birth and in the early years of growth). This calculation distributes the characteristics throughout the student population as we hypothesize they would actually be distributed. At this point in the computation we have estimated how many students are physically handicapped, how many might have exceptional ability, and so on.

Next we simulate the process by which management of a school district estimates the funds it will have available from normal sources and can obtain by special efforts, (passive or aggressive managements can be simulated). Having the funds available and knowing the characteristics of the student body and also having the previous year's operational results, the simulator models the process of management making allocation decisions, decisions about how to operate the school system for the coming year. This includes decisions to hire additional teachers, decisions to create additional space, and the allocation of funds between the various programs and activities (such as teacher development, remedial reading, the normal grade teaching, etc.). Next it simulates the process by which teachers are recruited and hired. (Hires are not necessarily equal to the number sought by the decision maker, depending on salary decisions and the market for teaching personnel). A detailed model would also simulate the characteristics of the teachers in terms of their ability, skills and effectivensss (a very difficult part of the model to develop). Next, the simulation computes the actual results of facility construction (which may of course lag behind or cost more than that scheduled by the decision makers). The result of this step would be calculations of space available for teaching. Alternatives, such as renting rather than building could be studied.

The next computation in Figure 3 represents the imparting of skills, knowledge, motivation, and learning ability to students by teachers. This, of course, is a simulation which will require intensive study to develop, as it models both teacher and student behavior. The result of this step is some increase in the knowledge and potential of pupils. This computation also estimates the effect of the teaching process and of environmental factors on administrative performance such as attendance, dropouts, perhaps disciplinary case rate, etc.

Next we can simulate the process of testing which will produce test results to be incorporated into measures of performance. The results of the tests will, of course, depend both on the nature of the tests and on the potential of the students as computed above.

The simulation proceeds by performing cost accounting calculations to determine the cost of the simulated processes: recruiting, construction, teaching, testing, etc. Next an estimate of actual funds available is fed into the computation. This model does not include the simulation of the funding part of the system and so a pre-computed estimate is substituted. In a complete model, available funds would be computed as a function of other community processes.

A final accounting produces a financial statement for the system. Thus, the simulation gives us two critical outputs -- a measure of performance of the system as it would be indicated by tests and other measures, and a financial statement. It also gives many intermediate outputs, such as estimates of teacher performance, and operating statistics such as the student per teacher ratio, and square feet of space per student, etc.

Obviously the most difficult sub-model to simulate is the teaching-learning process. If a start is made in the development of such a simulation it will have extremely beneficial effects in pinpointing what we have yet to learn about the learning process. Such a start can be made by reviewing past studies of the learning process, by new experimentation and by formalizing the educator's intuitive understanding of the learning process.

Measuring Performance

In Figures 2 and 3 provision is made to simulate the process of testing students. This part of the model is intended to provide a measure of performance for the system. The philosophy adopted here is the following:

The ultimate measure of an urban school district is the performance of its graduates in the community. Thus, the system must develop people who have many individual and community characteristics such as: being a good citizen, holding a job, contributing to the society, being happy, being a good neighbor, etc. A secondary measure of some of these is the general well-being of the community as measured, for example, by the gross regional product. These measures have a very long response time. We cannot use them to make decisions about what to do next year in the school. There must be some intermediate measure of performance which, on one hand, takes at most a few weeks (in real life) to determine, and which, on the other hand, is a good indicator of the more ultimate measures of performance. For this purpose we conceive that each class or group of students is periodically (yearly or more often) given a series of tests. The weighted sum of test scores and of other measurable characteristics (e.g., attendance) then becomes a measure of performance. These tests can include performance in gaming situations, and need not all be paper and pencil tests. Thus, they can be made more representative of the ultimate measures of performance than our present tests. (It is true that teachers will then try to teach so as to have students do well on the tests. Tentatively, it can be argued that, if the tests are well conceived, that this would be a good thing. It is exactly analogous to the concept of profit, the immediate goal for which every businessman strives and which, on the other hand, is presumed to be a good thing in the long run for the community.

The simulation permits the study of the effect of management decisions on both the performance attained as indicated by the intermediate measures and costs. Cost-performance tradeoffs can therefore be analyzed.

As the simulation is developed, a model which relates the educational process to the community may evolve. Then ultimate measure may be estimated directly. Future operational analyses of the school-community interaction might explore other measures of performance; for example, a concept of value-added. It might be possible to estimate the economic value added to the community by an educational process of a given quality. As the quality increases, the value-added should increase. Everyone agrees that the level of industrial and economic activity of a community must be higher if the children of the community have gone through a school system than if they have not. The value-added concept would be an attempt to formalize this intuitive feeling.

Representing Behavior

Given the success in predicting elections from early returns, we can now say that at least some forms of behavior can be predicted. [4] People often do not like to feel that behavior is predictable, but when we talk about the behavior of groups of people (and not individuals) it turns out to be quite predictable. However, behavior is still very complex. Therefore, simple mathematical models or simple qualitative statements are not successful in defining behavior. However, a computer model can often represent all of the complexities involved.

In addition to the election prediction scheme, we will mention three other experiments which show that behavior can be predicted. Cyert at Carnegie Institute of Technology has programmed a computer to perform the same decision making process that a trust officer performs in selecting stocks for a portfolio. [3] The computer did at least as well as the trust officer, and in general, chose the same stocks as he did. Greenlaw at Penn State has programmed a computer to perform the same analysis that an industrial psychologist makes to recommend or not recommend people for specific jobs. [7] The computer analyzed the raw test scores, just as the psychologist does to develop his recommendations. There is an extensive simulation model developed by Amstutz of MIT which represents the pharmaceutical market including physician prescription-writing behavior. He has also represented retail consumer behavior by simulation [2]

In each of these cases extensive study was required of actual behavior to develop the model. However, each of these models has been validated by experiments in the real world and their success indicates that the technique is useful. The operational analysis of a school district would be considerably advanced if we would begin to develop simulation models based on studies of the behavior of students, teachers, parents, and others directly affected as quickly as possible.

The Final Steps of Analysis

Once a model is operating, we would like to determine its validity. That is, we would like to be able to show that the outcomes predicted by the model are indeed those that would occur in actual life. It is extremely difficult to validate a very complex model for a system in which we cannot run experiments and within which the time responses are very slow. If we have to wait 10 years to determine the effect of a new teaching technique, it becomes discouraging to try to validate a model which has predicted the outcome of the introduction of that teaching technique. One partial validation procedure is to be sure that the model represents the behavior of the system over the past few years. A second validation technique is to be sure that each submodel, in particular, the behavioral submodels, represent the phenomena they are intended to represent as accurately as possible. However, in operational analysis of complex systems one will always be using models which are not completely validated. The only justification for the use of such models is that they offer more precise and comprehensive insights into the system than does any other approach as yet devised. Further, since the model would incorporate the intuitive notions of educators and others connected with the system, it should, in no case, make worse predictions that they could.

The ultimate test of the sophistication of a model might be this: Could it represent the behavior of the various decision makers and the various processes sufficiently well so that we could test such dramatic proposals as those made by Friedman [6] and others to, in effect, do away with a public school system and give every parent a subsidy for sending his children to an approved school.

We would hope, ultimately, to use models to study both extreme and novel proposals to evaluate whether the quality of education would increase or decrease and to evaluate whether the availability of education would be restricted or expanded.

Once the model is validated it would be used to study the system. Its use would depend on whether one was a researcher or a manager. The researchers would use a model to explore the nature of the interactions involved. They might study questions such as: What happens to the school system if we increase the total resources (particularly financial resources) available? What happens to its performance, if a sufficient supply of qualified teachers cannot be obtained? Can performance be increased through the use of non-certified personnel or through the use of computer-aided instruction? What is the interaction between space allocations and teaching performance? A whole host of such questions about the school system phenomena will occur to any reader. Through a series of experiments on the simulation model these phenomena can be studied. Interactions that appear particularly interesting might then be validated with tests in actual school districts.

A manager would want to use the simulation model as a tool for exploring specific policy actions under consideration. For example, if a school district proposes to introduce a major remedial reading program, the simulator might be used to evaluate the probability that the program will indeed improve reading performance, that it will improve general learning performance and also to estimate the total cost impact of the program on the system, not only for the current year but for future years.

Summary

Operational analysis can be an effective tool for gaining understanding of a complex system such as an urban school district. The steps required to implement the analysis involved:

- Identification of the system under study,
- Identification of the subsystems, the processes, flows and decisions,
- The development of a simulation model, which includes the development of models of behavioral and performance subsystems,
- The validation of the model by tests in schools,
- The use of this model to explore the system characteristics.

Such an operational analysis is expensive. It requires very talented people, skilled in operational analysis methodology, in education and in the management of school systems. A team effort is indicated. Extensive data gathering is required to obtain the parameters necessary for the model and to validate the key submodels. Nevertheless, the cost of such analysis -- possibly running into millions of dollars -- may be trivial compared to the benefits derived through the improved understanding of what makes a difference in the performance of an urban school district.

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