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ABSTRACT

Massachusetts' Management and Information System for Occupational Education (MISOE) arrays data for its dynamic simulation model, which decides educational and instructional policies at the state, school district, and classroom levels, according to this formula: Inputs/Process/Product/Impact. In this monograph linear programed models are distinguished from dynamic educational simulation. When least cost is not the chief consideration and when restraints on decision making are unknown, dynamic simulation constitutes a better approach. Implementation of dynamic educational simulation is advocated on a case by case basis, with the aid of experienced consultants. Although asked to deal specifically with design issues arising while planning MISOE so that necessary levels and rates could be obtained, the lack of examples of existing simulation models makes this activity premature. Creager assumes that there is no direct, formal relationship between static and dynamic analyses in MISOE. This document is related to VT 018 600 and VT 018 606, both developed by Creager, as well as VT 018 602 and VT 018 809. Available in this issue, these documents present an overview of MISOE in addition to numerous considerations involved in planning and setting up MISOE. (AG)

Occasional Paper #8

ON ORGANIZATION FOR DYNAMIC EDUCATIONAL SIMULATION

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ON ORGANIZATION FOR

DYNAMIC EDUCATIONAL SIMULATION

Inputs/Process/Product/Impact (IPPI)

The Management and Information System for Occupational Education (MISOE) arrays data for educational policy and instructional decision at the Commonwealth, school district, and classroom levels. As indicated in MISOE's 1971 Monograph, the data for each level will be grouped for convenience according to:

- Inputs (I)
    - Capital
    - Students
        - Characteristics
        - Descriptions
- Process (P)
    - Structure
    - Organization
- Product (P)
    - Number completing programs
    - Achievements of those completing programs
- Impact (I)
    - Effect of product on society
    - Effect of product on self

The arrays of IPPI data can inform many decisions in occupational education. In this Paper, I consider just one kind of uses, namely those requiring the formulation of educational policy at one level or another.

IPPI and Educational Dynamics

Policy decisions ought to be purposeful decisions. Purposeful decisions require deliberate structuring of circumstances so that desired results become more likely to ensue. The major purpose of MISOE is to permit use of its array of data so that policy decisions will be more rather than less informed and more rather than less desired. Policy decisions, like all decisions, will never be fully informed; there will always be room and need for judgment in all decisions. However, MISOE represents effort to bring data to bear on educational decisions so that areas of uncertainty are somewhat diminished in policy making and instruction. Doing so requires a shift in thought. Rather than merely thinking about the state in which the various parts of a system are at a particular time, we must think about changing states in each of the system's parts and how those things we can influence bear upon those things we want to change so that they will have a future form and quantity at costs we are willing to invest.

In order to bring about change we must think of the elements which make up the system in which change is to occur. We must also think of relationships among these elements. It is through the relationships that we are able to influence the system, that is to do something to some parts of the system which have the effect of altering the system as desired when the results of our original alterations run their course through the system. Doing all this requires a model. In this paper I consider a particular kind of model, a closed system model.

As Forrester (1961) notes:

> "The closed dynamic model is one that functions without connection to externally supplied (exogenous) variables that are generated outside the model. A closed model is one that internally generates the values

of variables through time by the interaction of the variables, one on another. The closed model can exhibit interesting and informative behavior without receiving an input variable from an external source.

Information-feedback systems are essentially closed systems. They are self-regulating, and the characteristics of principal interest are those that arise from the internal structure and interactions rather than those responses that reflect merely the externally supplied inputs." (pp. 51-52

Internal dynamic interactions are of principal interest in closed systems models. However, according to Forrester, closed system models need not always be studied in completely closed form. He elaborates on this as follows:

"... It is often informative to depart from strictly closed operation enough to permit a test input that serves as excitation of the internal responses of the system. Impulses, steps, sinusoids, trends, and noise (random disturbances) are common test inputs. Such external (exogenous) inputs are valid only under conditions where we are willing to assume that the external inputs are themselves entirely independent of the resulting response within the system." (Forrester, 1961, p. 52.)

Forrester has developed a procedure of industrial dynamics which he has applied successfully to production management in industry as well as to policy issues in urban and world dynamics. MISOE has elected to adapt this model to the dynamics of educational decision making in occupational education. This Paper on educational dynamics furthers that intention by formulating and commenting on some issues involved in using MISOE data in a dynamic educational system model.

Structure of the Dynamic System Model and Its Adaptation to Educational Decision Making

Structure. As indicated, IPPI (Inputs, Process, Product, and Impact) are the basic elements of the dynamic system model of MISOE. In general, inputs are to be fashioned into products so that the products impact in desired ways. Process, the "fashioning," constitutes the means whereby the inputs achieve their impact through the intermediate condition of being "product." In this basic system, care will have to be exercised in considering the operation of money in the system. In one sense, the capital of the system does constitute an input; it is a given from which the operation of deliberate change starts. However, when money is to be added or subtracted from the system, it in turn becomes process, that is money becomes another of the means whereby others work with students to fashion them into the products which will impact as desired. Similarly, care will have to be exercised in interpreting "structure" in process. Structure must not just mean the fixed elements of the system; it must incorporate the functions which are exercised within or by the system as well.

These conditions become clear as one works with the Forrester model. In that model all elements must be organized into desired relationship with each other because the model implies a closed system in which each element works in potential on all others through definitely designated functions. The basic elements are levels and rates. Levels in the present time are influenced by their respective rates which operate in the change interval to deplete or augment their levels in accord with lawful functioning of the system by its equations. The Forrester dynamic model is thus a closed system calculus which permits one to depict consequences of various operations (processes) on the several conditions which one seeks to influence or control in the system.

Operations (processes) have their effect on the dynamic system calculus through rates. Rates are in turn influenced by information, the only part of the system which does not have immediate metric and functional relationships. Information is the avenue by which the human in cooperation with the simulation can insert new rates, allow the system to take its next step operating upon that new rate, observe the result of the new calculations, and act to change rates still a succeeding time.

The structure of the dynamic system model is described quite fully in Occasional Paper Number 6. This description essentially 1) introduces simulation as a management system tool, 2) presents the dynamic system model, 3) defines levels and rates which are the two primary characteristics of the dynamic system model, and 4) gives examples a) of a simulation at the level of the legislature considering education as one of several means of obtaining desired social outcomes and b) of the Assistant Commissioner of Occupational Education implementing the general decisions by the choices then available to him. This paper presumes familiarity with dynamic educational simulation. A good account of dynamic educational simulation can be found in MISOE Occasional Paper #6, pp. 35-73 by Dr. Conroy and Ms. Weinberger. Additional background on its essence and nature can be found in Chapters 5 and 6 of Industrial Dynamics by Jay W. Forrester.

Occasional Paper Number 7 presents a number of noneconomic considerations which must be taken into account in the design, implementation, and conduct of MISOE. However, also included in that paper are two sub-sections ("General Considerations of Dynamic Simulation," pp. 62-64 and "Equations and Data Sources," pp. 64-69) which elaborate on the dynamic model and comment on some of the potential relationships between the static information which will exist and be processed in MISOE and the levels and rates which will be required in dynamic models.

Adaptation in General. I hazard the guess that MISOE staff in constructing the actual dynamic system model exemplified in Occasional Paper Number 6 realized that the levels and rates bore little or no correspondence to data it had so far imagined would be stored in MISOE. I ask that this assertion be evaluated, accepting a distinction between facts and data which I found very useful in designing the Information System for Vocational Decisions (ISVD). In the first report of the ISVD, I defined needed distinctions among facts, data, and information as follows:

"... Facts/data come in two conditions, fixed and modifiable. ... Facts are directly recoverable without modifications except for storage and later retrieval. On the other hand, ... data consist of facts which must be additionally processed by the numerical and/or linguistic routines of a modifying system. Either unmodified facts or previously modified data need to be further mediated if they are to be turned into information. This is why we refer conjointly to facts/data whenever our connotation is associated with information." (Tiedeman, 1967, p. 2)

When I refer to data in this Paper, I shall limit my consideration as above to facts which have been processed prior to their present or intended use. It is within this meaning of "data" that, in studying the dynamic simulation model in Occasional Paper Number 6, I concluded the needed levels and rates probably bore little or no correspondence to data so far imagined for MISOE. This impression centrally determines the structure of this Paper. I have been asked to direct my attention specifically to the design issues arising in planning MISOE so that levels and rates needed in dynamic educational simulation can be fairly readily available when needed in dynamic educational simulations. It is currently my considered opinion that such an activity is presently premature. The levels and rates which one wants to have actively available for dynamic educational simulation depend on the models which one will be using. There are no existing dynamic educational models which we can use to establish the kinds of rates and levels which will be needed more frequently in the future. Effort might therefore better be directed toward elaborating examples of dynamic educational simulation and delaying until a later time the evolution of a theory of functions which allows one to pre-plan a part of MISOE dealing specifically with the data of rates and levels for dynamic simulation.

Creager (1972) is available to speak for himself in MISOE. However, it appears from his Occasional Paper Number 7 that he also had doubts which I have now stated as my opinion and advice. For instance Creager writes as follows:

"Discussions with the staff revealed an expectation that some dynamic simulation models could be predesigned for call with specified parameters. In so far as this is practical, i.e., certain completely general and specifiable models can be developed for clearly anticipated general forms of inquiries, the notion is an attractive one. It would seem more likely that variations in the detailed nature of the inquiries received by MISOE will imply variations in the details of the simulation flow charts and equations. If this is correct, much greater flexibility will be needed in formulating dynamic simulation models than one would have from a small set of prepackaged models. The latter flow chart form may be initially helpful as a communication device with managers, and as a nucleus chart for the staff to elaborate in formulating specific models for specific inquiries." (p. 63)

The idea is attractive beyond doubt. A developed capacity permitting an administrator facilely and readily to see the money and achievement consequences of the several options which leap to his mind as he wants to improve and make education more economical represents a Thinking-With Machine avidly to be sought. Unfortunately, the gap between the hope and the realization in computer arrangements for fact and data storage permitting almost instantaneous information creation is enormous. The design art for intermediate fact processing which will bear economically effective relationship to use patterns in dynamic educational simulation has yet to be born.

The trade off which a system manager has in designing data for his system is that between time and money. The manager must invest money in order to buy time which he hopes to save in the future. His choice is between leaving facts as they now are and including the time and cost of turning them into the data needed for information creation in the specific job requests which he gets or engaging in processing facts into intermediate data levels in slack times against only anticipated future demand. Each situation has and will have its own pecularities. No general rule can be forumulated. However, the Project TALENT Data Bank has now existed for seven years. In these years, funding has never been sufficient to provide all the fact processing which is considered desirable for storage as data against anticipated requests. This Data Bank therefore makes the consultation process central in its operation and assesses costs for data processing in information creation on each project as requests arise. My current guess is that MISOE will have to adopt similar policy in the realm of dynamic educational simulation.

Creager (1972) holds forth the following promise for pre-use data processing in dynamic educational simulation:

> "As the staff accumulates experience in designing models for answering specific inquiries, portions of these models may be used as modules, which can be put together in various ways to form the initial flow charts for future inquiries. In this approach the same level and rate equations may be used in the new models wherever those levels and rates are <u>not</u> changed by their connections to other levels and rates. (This suggests that the user-defined MACROS in DYNAMO may be useful to MISOE.) Some types of modules that may thus develop over time, and may be repeatedly used include student flow subsystems, economic allocation subsystems, and certain kinds of information loops. It is likely that different modules developed in connection with an inquiry from some level of management will be most useful for inquiries coming from the same management level. How feasible or how helpful such a modular approach may be in MISOE requires further consideration and, possibly, actual operating experience. It is suggested here as a compromise between having a repertoire of a few general models and having to derive ad hoc models from scratch for every inquiry." (pp. 63-64)

Creager's suggestion seems reasonable. As experience accumulates, the staff will find that certain parts of models in its prior experience can be adapted to new inquiries. As such experience grows, it would be advisable to build in means to finance the developmental and implementational work then needed to create such data systems on a more general basis. However, further investment towards that end does not appear immediately advisable at this juncture in the understanding of dynamic educational simulation.

One exception to this advice ought to be considered. In MISOE, the facts of a lower educational level can in general be the data of the next higher educational level. In order for the lower level facts to become the data of higher level decisions, they must be aggregated. It would therefore seem useful to determine and store aggregates of the first and second powers of basic lower level facts, both weighted and unweighted, as the first order data for further data processing in higher order dynamic simulations. This would facilitate the computation of levels in the dynamic simulations. To the extent that the rates of dynamic educational simulations are also functions of levels, it would also facilitate determination of rates as well. However, the likelihood of anticipating data needs for rates is far less than the likelihood of anticipating data needs for levels.

Some Specifics of Adaptation. Although Creager was assigned responsibility for design considerations primarily in static analyses of MISOE, he was informed about dynamic educational simulation and fortunately provided many direct suggestions about the way in which facts and data of the static analysis files might or could relate to the facts and/or data of the dynamic educational simulation files. For the sake of the record, I herein note that those suggestions are to be found on the following pages of Occasional Paper Number 7: 2, 4, 11, 12, 19, 20, 24, 25, 32, 33, 37, 39, 40, 52, 54, 57, 59, 60, 70, and 83. These suggestions are in addition to the two complete sub-sections on pages 62-69 of the Paper to which I referred earlier.

In general, Creager took the position that there is no direct, formal relationship between static and dynamic analyses in MISOE. I concur in this assumption. I too feel that there is no way to go from static analysis to dynamic analysis by a process akin to that of mechanical language translation. That is, there are no before-use rules which can be written to relate the facts/data of static analysis to the facts/data needed in various dynamic analyses. Or more exactly, such before-use rules as can be written are likely to prove so inadequate that the dynamic data created by them will never be trusted in policy-making. Direct translation from static to dynamic analyses will be as necessary in dynamic educational simulation as it has proven to be in language translation. The computer can help in language translation; it has so far not been fully programmed to translate directly so that fluent passages result.

Since Creager assumed no direct formal translation possible from static to dynamic facts/data, he largely commented in Occasional Paper Number 7 on how analyses can be used to focus on a reduced set of data which are likely to provide useful facts/data in dynamic analyses. Since Creager is the fine craftsman he is, it should come as no surprise that I take little exception to his comments of this nature. There are, however, the following places in which I offer a caveat or two:

1. On page 20, Creager asserts that "... except for capability of computing Phi coefficients and Chi-square statistics (from weighted frequencies), the need for nonparametric statistics is judged to be low and therefore of low priority for MISOE." As I indicated in meeting during 20-21 June 1972, the fact that MISOE will rely heavily on criterion-referenced tests dictates need for nonparametric statistics. In the first place, criterion-referenced tests are deliberately kept as nominal or at most ordinal scales. Therefore, scores from them will not achieve the interval property which is assumed in parametric statistics. In addition, the essential idea of criterion-referenced measurement is to have a number with a meaning, not necessarily a scalar. Therefore, non-parametric statistics are much more likely than Creager indicates to be essential parts of MISOE analyses.

2. On page 32, Craeger asserts that "... the plotting of aggregate census data and of appropriately weighted sample data against time should provide some of the rate functions and some of the modifying auxiliary functions required for dynamic simulation, which is MISOE's major approach to coping with the temporal aspects of the state system of education." I feel sure Creager understands that MISOE's interest in dynamic educational simulation is much different from simply coping with the temporal aspects of educational management. MISOE needs dynamic educational simulation to give educators who do their part in bringing civilization forward opportunity to understand their options and the consequences of each better than one can without a calculus of educational

product-making and impacting. But my major point in relation to Creager's advice is to warn that rates in dynamic educational simulation are more than the free variation of something in time. Rates in dynamic educational simulation are informationally-guided statements of what you want a level to change into during the ensuing cycle in which the rate operates. Hence, plotting existing levels as a function of time can inform interested people in what is going on; the rates inferred from such diagrams should not be mistaken for the rates which will be needed to secure informationally-guided operation in a dynamic educational simulation.

3. On page 57, Creager asserts "... it is likely that 'full models' with pertinent interaction terms will procure the kinds of parameters needed in dynamic simulation." The "full model" to which Creager refers is that which comes from analyzing by regression analysis variables in the several IPPI spaces, first separately, and then simultaneously. Although such analyses will inform the discerning analyst about what has been going on among these variables, care should be exercised at all times to distinguish the purposes of dynamic simulation from those of analysis. In analysis, one seeks to determine what has happened. In dynamic educational simulation, one seeks to make be that which he wishes. It is true that reasonable men ordinarily attempt to change things evolutionarily rather than revolutionarily. Reasonable men therefore have to guide their wishes and desires by thorough understanding of present and past conditions. However, reasonable men must also always understand that change involves an act of discontinuity, not the uniterrupted operation of continuities. Therefore, something different has to be done to produce change; you can't just wait for nature to take its course.

4. On page 57, Creager also asserts "... it may be that including economic data in regression analysis will be useful to help identify the

important variables, whose levels need to be included in simulation models, but to use elasticity coefficients, rather than regression coefficients in rate equations." I have little knowledge of "elasticity coefficients" so I have no reason to question the latter part of this assertion. But remember economic variables will more likely be used as means whereby effects are achieved than as the effects themselves. As process variables in this sense, the potential value of money as a change function is not likely to be revealed in any kind of regression analysis. It will practically always have to play the role of change creator.

5. On page 59, Creager asserts "... it is in problems with strong nonrecursive, nonlinear, and temporal flow features where dynamic simulation will be most clearly indicated." It is true that dynamic educational simulation has nonrecursive, nonlinear, and temporal flow features. However, it will be a mistake to choose dynamic educational simulation merely for that reason. Dynamic educational simulation is a procedure which allows one to see what happens when he deliberately tries to influence a system; it shows potential effects and in doing so suggests to discerning individuals what needs to be done in informational adjustments of rates to achieve desired effects. Dynamic educational simulation is not an analytic tool; it is a speculative tool. When one wants to analyze, one should not trouble with dynamic educational simulation even though one's data are nonrecursive, nonlinear, and temporal. When one analyses one should use a model appropriate to the nonrecursive, nonlinear, and temporal conditions which one assumes are operating.

Linear Programming and Dynamic Educational Simulation. On page 60, Creager asserts "... with such a least cost formulation and clues to the relevant variables, MISOE might recognize this as a linear programming problem, to be solved with the simplex algorithm, minimizing the total cost under the constraint that the number of square feet of floor space for a given number of engines is more than some specified constant." In a subsection beginning on page 73 under title "A Pseudodynamic Model as Nonlinear Programming," Creager goes into this theme more fully. I judge from the cited work as well as from the meeting on 20-21 June 1972, that MISOE needs and will get a distinction between linear programming and dynamic educational simulation. In seeking this distinction, I trust that MISOE does not miss the major distinction I have made between analysis and dynamic educational simulation.

As I have indicated, in analysis one seeks to disarticulate an effect from a larger whole. You therefore start with the whole and attempt to dismember that whole so you can secure understanding of elements and relationships among its parts. In dynamic educational simulation, the whole does not exist at the start. Instead, you attempt to work with some data and a number of assumptions to see if you can construct a picture of what is likely to happen keeping such a picture corresponding to what you know has occurred as well as with what seems reasonable in its future operation. As you do, you keep the system closed as dynamic educational simulation assumes. Thus, in dynamic simulation you seek a system in which repeated input of resources guided by informational feedback of what has just occurred from a prior act will create from parts a whole which is desired and constructed as a closed system.

The purpose of linear programming is therefore different from the purpose of dynamic educational simulation. In linear programming, there are a set of constraints and one seeks a maximum or minimum solution within these restraints. In dynamic educational simulation, there are a large number of conditions which are known to be unreasonable and one seeks an optimum (not necessarily a maximum or a minimum) solution or sets of solutions which narrow the realms of previously existing uncertainties. As Herbert Simon (1960) notes:

"<u>The central concern of administrative theory is with the boundary between the rational and the non-rational aspects of human social behavior</u>. Administrative theory is peculiarly the theory of intended and bounded rationality--of the behavior of human beings who <u>satisfice</u> because they have not the wits to <u>maximize</u>." (p. xxiv)

Linear programming solutions in decision making press models into the realm of maximize (or minimize as the case may be). Dynamic educational simulations let administrators and others operate to satisfice. We should, of course, always strive to push the rational ever further into the frontiers of the non-rational. However, let us do something today even when we lack full solutions. This is particularly needed in education because there are always among us those who know how to do better what we do today but these people ordinarily do not have the time to do that which we educators have to do today even though it is not that step further toward perfection which it could be.

Although dynamic educational simulation is likely to reveal how complex system conditions operate even when it proves impossible to derive exact linear programmed models for what one seeks to maximize or minimize, the power of dynamic educational simulation is greater than this rather weak advantage. Dynamic educational simulation provides a means whereby the decision maker can see how a set of variables function interactively and directionally under informationally-guided intermediate decisions about rates. In this operation, cost may be a consideration but it does not have always to be the major consideration. It is necessary to know that one can get something he seeks before one needs to begin to worry whether the route he is taking is that of lesser or least cost. Dynamic educational simulation will operate in this more relaxed relationship to cost. Linear programmed models ordinarily function primarily in terms of least cost. When least cost is the major consideration and when the restraints on decision are known as in Creager's illustration and that of the Assistant Commissioner of Occupational Education given in

Occasional Paper Number 6, linear programming is the appropriate solution. But when least cost is not the major consideration and when the restraints on decision are not known, dynamic educational simulation ought to be the preferred method of attack.

On the Consulting Process in MISOE

In this Paper, I have argued that dynamic educational simulation is a new field and therefore best approached by MISOE case by case in the future. I realize that MISOE plans to secure help from Massachusetts Institute of Technology for a frontal attack during 1972-73 on the problem of specifying a theory of functions for levels and rates which will permit the System to process and store facts and data of static analysis as potential facts for dynamic analysis. However, I am still pursuaded that the major next problem is thinking up the examples of dynamic educational simulation, not that of devising a theory of its functions which will facilitate the retrieval and processing of facts/data from static analysis. My own experience suggests that the state of the field will likely remain in an example-impoverished condition for another five years or so. Dynamic educational simulation represents complexity in educational decision making and management which is not yet common experience. Devising examples represents major professional effort, not investment-free puzzle inventing.

For these reasons I advocate implementation of dynamic educational simulation on a case by case basis. Have the fact and data file in prime condition for static analyses and it will be in the best possible preliminary condition for each new example of dynamic educational simulation. However, consulting with a person needing a dynamic educational simulation and having the capacity to engage in additional fact and data accumulation upon demand are both likely to be necessary for each new dynamic educational simulation. Therefore, previously unassigned funds will be necessary to carry on the work needed when a new request comes in for dynamic educational simulation. Furthermore, time is likely to be at a premium when these new requests appear. Therefore the consulting process will be critical. Looking ahead we can anticipate several specific things about the consultant and his process.

The consultant needs to be familiar with MISOE and with educational dynamic simulation. Since there are not many educators who are familiar with dynamic educational simulation nor industrial dynamics specialists who are familiar with education, it is likely that two specialists will have to cooperate in the consulting process. One specialist should be an educator keen on numeric analysis who learns quickly in the field of dynamic educational simulation. The other specialist should be a person trained in industrial dynamics and the computer operation of DYNAMO with interest and aptitude for education and its economics.

The consulting process will require quite a bit of time for conversations among the person who wants a dynamic educational simulation and the two MISOE consultants specified above. In addition, the two consultants will have lots to do together.

The consultation scenario might go like this:

1. There will be a familiarization period during which all three parties discuss the problem and its possible solutions.

2. There will be an exploratory period in which the two consultants begin to fashion crude models which will be discussed with the person presenting his problem.

3. There will be a rather long data collection and processing period in which the necessary factual data are assembled and put into condition for use in the several rough models.

4. There will then be a trial period in which the several crude models are specified sufficiently carefully so that dynamic educational simulation can result.

5. A preliminary reporting period will ensue in which these trial runs are shared with the client.

6. Next will be a revisionary period in which the one or more models are revised and retried.

7. Hopefully the revisionary cycle will occur only once and the new reports can then be shared with the client for his interpretations and use in a final reporting period.

Each model represents a new theory on the operation of IPPI elements at one or another of the educational levels MISOE serves. Each example therefore ought to be accepted with care for widening System experience. Furthermore, time and money will be needed to make each come into being. However, if the client doesn't expect results overnight, his participation in a problem with potential for new theory by means of a consultation process such as I have outlined ought to carry him over the rough nights when he will wish he had never started. This will be particularly true if both the educational and the industrial dynamics consultants have the capacity to help this client comprehensively see the generality in what he seeks and asks and they provided. It will not be true if the consultants can share only the detail they will have to provide in getting approximations to the needed answer which they are capable of achieving. The detail will be of interest to the consultants, not the client. What will interest the client is how detail empowers him to think more totally.

Organizing for Dynamic Educational Simulation

this Paper, I placed myself squarely in favor of dynamic educational on as a form of calculus permitting an educational decision maker ity to ascertain the consequences of different policies he might pur- ttempting achievement of goals he defines as he seeks. The value of educational simulation rests in the fact that levels of otherwise fixed ns can be transformed at uniform intervals by the model into new levels the medium of rates controlled by information or policies. The exercise el once constructed gives the decision maker facts/data on what aspects odel tend to take its consequences into later states which are untenable reposterous. In this regard, dynamic educational simulation provides king decision maker with valuable information we ordinarily don't value, nformation on what not to do. But the negation of possibilities ordinarily ome of considerable value as one begins to find solutions in dynamic edu- simulation which remain tenable and/or credible -- i.e., you then also some contrary alternatives don't pan out when you meet someone who he solutions which you offer.

lso took the position in this paper that effort ought momentarily to be toward elaborating examples of dynamic educational simulation rather ard unstinting evolution of a theory of functions which allows one to a part of MISOE dealing specifically with the data of rates and levels nic simulation. I did so on grounds that examples of dynamic educational on are presently quite scarce. I therefore felt that time and effort e devoted to the assembly of models before additional time and effort be devoted to their generalization into a theory of functions permitting ect user access to stored facts/data directly bearing on a model never onstructed.

I then took the position that financially and politically it would be better to assess new model construction costs on each interested future user than currently to provide a fully financed MISOE sub-organization which is dedicated to the construction and generalization of dynamic educational simulations. I finally suggested that consulting be the essential process which temporarily permits MISOE to provide the capability for dynamic educational simulation in the absence of an assemblage of simulation models and a theory of functions permitting consultant-free use of the System.

Obviously, longer-range perspective for MISOE dictates that organization for the assembly of dynamic educational simulation models and their generalization to more consultant-free use by means of a theory of functions of levels and rates ought to be built in at MISOE's inception. But I personally suggest that such organization remain only implicit in the Director of MISOE for the first several years. If the Director assimilates the end of constructing a theory of functions in dynamic educational simulation, he can select examples on which he assigns his two consultants so that they are both the specific manifestation of what the buyer wants and a general example of what further construction of the needed theory of functions requires. Such selection will prove difficult at first. Buyers will be scarce. Choice will be infrequent. But choice can still be present, however infrequent, if the Director always thinks along such lines as he drums up and reacts to business through his organization.

A second condition needed to create a climate conductive to the generalization of specific examples into a theory of functions about levels and rates in dynamic educational simulations is a dedication to research and writing on the part of those who consult with MISOE's users of dynamic educational simulation. These consultants must be aware of the System's need for a theory of level and rate functions and must consider their work example by example in the light of this need. Consultants who do so under such expectation and leadership from the Director are likely to contribute the desired generalization to a theory of functions.

As examples and writings accumulate, the Director may find need to create a formal sub-organization dedicated to research within MISOE. I would personally introduce the research sub-unit in general before I would sub-devide that unit to include one which specifically dealt with research on dynamic educational simulation. The needs of MISOE will be considerable. Hence, the Director will probably quickly realize the necessity of dividing the System into Operational and Research units. The Director may thereafter struggle through a short period when Operations are Research. However, I believe he will eventually come to the realization of all computer systems directors, namely that you have momentarily to freeze Operational systems for sake of accuracy and efficiency while you isolate Operations from Research in order to keep the potentially better but still not adequately functioning ideas of Research from always stalling the production of Operations.

When MISOE has a Director of Research serving under the System's Director, the System Director should make the Research Director responsible for developing the needed theory of functions which will free MISOE from the human consultation function more and more. This represents a statement which the System Director should both consider in defining the needed qualifications of his intended Research Director and act upon while installing his hired Research Director into his work.

After several additional years of growth pass and after the System Director and Research Director have a sufficient number of conferences about why the

Research Director isn't advancing a theory of level and rate functions in dynamic educational simulation sufficiently fast to suit the System Director, the Research Director will discover that he needs a Director of Research in Dynamic Educational Simulation. When he does, the Research Director should repeat the process which his System Director used on him. At this time, MISOE may well then have the person with the full capability and time needed to create the desired theory of functions in dynamic educational simulation.

Mono-converging thinkers may well throw up their hands in disgust at my seemingly devious but certainly lengthy process of getting MISOE what I think it will ultimately need. I do so merely because my experience -- and that of many others who before me attempted quickly to secure massive support of computer-grounded systems to little avail -- indicates that the economics of support must creep before they can fly. The countryside is somewhat littered with government financed research systems which can do magnificent things but are not in use because no one pays for them. The answer seems to be that computer-involved management systems always require the education of the user as well as the provision of the system. It is therefore necessary to use multi-converging thinking in creating a money generating function for supporting MISOE, that is; (1) to get some dynamic educational simulations going, (2) to encourage those who need them to look at them, (3) to get those who look at them to pay for some of them, and (4) only as you begin to have such a market to trouble to go for improvements that make the System better and the market greater. It will be when MISOE has a few customers that MISOE's Director will find himself busy enough to hire two lieutenants who will share his work in Operations and Research. It is only after the Research Director has in his turn proven his capability to give MISOE a reasonably steady flow of new operations which sell that he will find himself busy enough to recognize that he must share responsibility with a lieutenant of his in order to solve the truly knotty problem of a theory of functions governing the consultant-free use of levels and rates by potential future users of dynamic educational simulation in forms individually desired by them.

At this time an organization will have come into being within MISOE. Such an organization which is encouraged to develop along some of the lines of my reasoning would hold promise of continuation; it would be based on a user market and not alone on Department of Education funds. The line of development I advocate would take longer. I just think it would last longer.

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