PROGRESS TOWARD A PROPOSED SIMULATION GAME BASE FOR CURRICULA IN DECISION SCIENCES

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ABSTRACT

Use of a special purpose business simulation game as a laboratory vehicle throughout a decision science curriculum is proposed as a pedagogically useful device for achieving curricular objectives. Development of such a game and its requisite characteristics are described. The multi-level nature of the game dictates that major subsystems must exist at different levels in order to incorporate dissimilar decision situations confronting players in various courses. Modular design is the means by which certain multi-level features are incorporated and permits one to "tailor-make" the game for a particular application. Economies, analogous to overlays in FORTRAN, are achieved since only those program segments or subsystems representing degrees of decision complexity actually present must be stored and executed in core.

Many curricula have been designed to imbue students with the Decision Science philosophy. (The reader is probably familiar with these attempts under such titles as scientific management, operations research, management science, or quantitative business analysis.) For the most part, such programs have been charged with severely limited success in that they have not met the major objective of all Decision Science curricula: to train effective situational problem solvers. Instead, new graduates of such programs tend to be sophisticated theoretical modelers whose value to business and industry is limited by their narrow technical viewpoint.[1] Their subsequent paths of development are highly individual, and depend not only on personal characteristics, but also on whether they find niches in research-oriented organizations.[2]

CURRICULAR VEHICLES

Traditional Vehicles

Traditional vehicles used in Decision Science curricula include mathematical exercises, "word problems", cases and project assignments. While each of these contributes, to some extent, to the accomplishment of the aforementioned objectives, they are all severely limited. Mathematical problems are useful only for teaching theoretical nuances and mathematical manipulation, and no situational elements are involved. Word problems include a few more situational elements, but do not adequately reflect the dynamic characteristics required for situational problem solving. In addition, word problems tend to be so brief that neither the choice of technique, nor the identification of relevant data provides an important challenge to the ingenuity of the textbook-wise student. Cases may reflect situational peculiarities much better than either of the foregoing types of problems. Unfortunately, cases are static in nature and, based on the experience of the authors, relevant cases appear to be in short supply. Project assignments can offer students practice in situational problem solving but, due to typical course time limitations, don't provide students an opportunity to fully examine the situational impact of their recommendations.

Traditional Vehicles

Consideration of the limitations of traditional vehicles might lead to the conclusion that practical experience is the only instructional vehicle capable of meeting all the objectives of a Decision Science curriculum. However, this is not the case, since real-world experience is limited by its inaccessibility to most students. Furthermore, most significant real situational problems are too complex for students' initial learning experiences. There is, however, one additional instructional vehicle available which, when appropriately used in conjunction with the traditional vehicles, may meet all of the objectives of a Decision Science curriculum. This vehicle is simulation gaming.

A Laboratory Vehicle

The authors contend that: (a) a

simulation game can be used throughout a Decision Science curriculum to integrate the various topical areas and to provide a laboratory situation in which students can obtain experience in all phases of Decision Science;[3] (b) a game to be used for this purpose must have some very special characteristics not included in existing widely used games; and (c) a game with the requisite features can be and is being developed by the Operational Gaming Group at Georgia State University.

The other reasons for using a game throughout a Decision Science curriculum involve the general features and inherent student appeal of such a game. First, simulation games are dynamic in nature. This feature allows students not only to make decisions at different points in time in a competitive simulated environment, but also requires them to observe and live with the results of those decisions. Also, the documentation accompanying such a game gives the student experience in analytical examination of written descriptions of situational problems, and in screening management reports for relevant data. Further, use of a game throughout a program provides continuity not possible with the use of any other vehicle. The fact that a simulation game is somewhat less complex than "real-world" situations eases the transition to "real-world" problem solving. Still, simulation games can, by design, be complex enough to demonstrate the systemic interactions between decisions in several functional areas of the enterprise.

An aspect not to be omitted is the impact on the organization offering the curriculum; typically a school or department within a university. While simulation gaming has compelling advantages as a teaching vehicle for Decision Science, it is undeniably expensive. Two highly significant expense elements are game development and user (instructor) training. By the choice of a single game package as the vehicle for an entire curriculum, it is expected that considerable economies may be realized on a per course basis as compared with a totally independent choice of vehicle.

Even if none of the attributes mentioned above was present, the quality of student appeal in simulation games would make their use worthwhile. In our experience, no other vehicle appears to be capable of generating student interest and motivation to the extent that simulation games do.

In order to meet the objectives of a Decision Science curriculum, it is necessary to develop in students an awareness of the need for, abilities of, and limitations of quantitative techniques. Simulation games appear to have a unique ability to create student demand for relevant quantitative techniques[4]. This is probably because the simulation game may require students to make decisions in an environment where obviously relevant data is present but where no explicit instructions are given for its use. Thus overloaded with information, students then become highly receptive to quantitative techniques which lend structure to this environment and which provide information that can be used in arriving at decisions.

REQUISITE GAME FEATURES

It was mentioned earlier that the use of a single game throughout the curriculum would lead to economy of vehicle development. If the desirability of using simulation games in a Decision Science curriculum is accepted, philosophical considerations also dictate the use of a single game. Student participation should be concentrated on acquiring experience in decision making and on using quantitative and behavioral techniques as inputs to the decision process, rather than on deciphering the documentation of several different games. The single game limitation imposes some rather stringent requirements on the design of such a game. These requirements concern the simulated environment, complexity, flexibility, adaptability, and documentation. The game under development at Georgia State University will incorporate the requisite features outlined below.

Simulated Environment

Since the game is to be used throughout a curriculum, it will be desirable to be able to focus on different subareas independently or simultaneously. A generalized business environment is probably the only one which will adequately cover the various areas where decision problems arise. The specifics of the environment are less important than the requirement that it must be possible to display the environment at a variety of levels of detail.

An appropriately designed business environment should provide potential decision making opportunities at a variety of organizational levels ranging from repetitive short run operational decisions at a lower middle management level to top management strategic decisions of great long range consequence. On another scale, the decisions should range from relatively mechanistic ones in which the outcome of a given action is highly predictable, through decisions in which uncertainty is a factor, up to those where the unknown future competitive actions of an opponent are critical.

Complexity

Several complexity considerations are important. First, the game must be simple enough that the student is not overwhelmed by its intricacies in his initial experience with it. At the same time, it must be complex enough that the problems and solutions are not obvious. Finally, its potential must be sufficiently rich to sustain student interest throughout a curriculum.

Flexibility

The use of the same game throughout the program and the need to focus on different subareas independently and simultaneously have some powerful implications for the structure of the computer program. During the early stages of the curriculum, it will be desirable for the student to be exposed to all subareas simultaneously, but in a very simplistic fashion. During the intermediate stages, it will be desirable to focus on highly sophisticated decisions in one or a few subareas while suppressing complexity in the remainder of the subareas. During the final stage of the curriculum, it will be necessary to pull out all the stops and allow the game to operate in its most complex form. The need for flexibility requires that the game be modular and multi-level. If, for example, the primary focus is on the production area, there must be a marketing module which operates in simplistic fashion. However, since in other cases the desire may be to focus on marketing, a sophisticated marketing module must also be built. Still another flexibility requirement dictates that it must be possible to configure the game in such a way that outside "role play" can be superimposed on the operation of the game in a realistic and relevant manner. Likewise, it must be possible to incorporate the impact of one time outside effects such as strikes, anti-trust action and surtaxes for excessive retention of earnings.

Adaptability

Since the game must be operated in several different configurations, it is necessary that the changeover time and effort required be small. The game administrator should be able to choose the desired configuration easily; for example, by specifying one parameter value for each subarea, thus specifying a set of decisions which are to be held open or closed. Another arrangement might be through merging desired modules with a base program to create a custom-tailored program with the desired combination of simplicity and sophistication. While this would be rather more demanding of the instructor (who may not be assumed to be sophisticated in the technical aspects of gaming), a richer variety of options can be provided in this manner. In such fashion, the game can be tailor-made to each specific course in the curriculum.

Documentation

Naturally, operating the game in different configurations will prohibit the use of a single documentary unit for all applications. Consequently, documentary adaptability must exist to the same degree as does computer program adaptability. A background environment description should be written which is general enough to provide the student with a broad understanding of the general business environment of the game without detailing the specific decisions to be made. Then, for each module, a set of documentation must be prepared, one for each different level at which the module can be operated. These can also be coded so that the modules chosen by the game administrator to specify a particular configuration will also specify the appropriate background documentation and decision forms to be provided for the students. Additionally, an instructor's manual must be prepared to aid the instructor in choosing the game configuration which will best meet his objectives.

Game Development

Unfortunately, any single game in current use is woefully inadequate for use in such diverse configurations, although there are several games available which are admirably adequate for achieving specific goals within particular environments. This is not surprising, since most games were written to achieve selected objectives within given environments. Another limitation of existing games is the quality of the accompanying documentation. Many games have been written by individuals or by small teams. Such games and the accompanying instructions tend to reflect the special areas of interest of the authors. Coverage of areas peripheral to the areas of interest of the authors is given only superficial treatment . . . A final limitation of existing games is the level of sophistication required of the participants. Here again, special purpose games are often written for audiences at specific educational levels. As a result of the limitations of existing games, it is necessary for game administrators to learn, implement and administer different games in order to achieve specific purposes for differing audiences.[5]

Recognition of the limitations of

existing games for accomplishing the objectives of a Decision Science curriculum spurred the Operational Gaming Group within the School of Business at Georgia State University to embark on the development of a game which would include all of the requisite features above. The Operational Gaming Group consists of a number of faculty members, each of whom has expertise in some area important to gaming. Participants in the Group are: Geoffrey Churchill, Chairman; Sandra Beldt; Merwyn Elliott; David Ewert; Dennis Grawoig; Elbert Greynolds; Edwin Heard; Don Jewell; Arthur Nichols; Brian Schott; Dwight Tabor; and Jerry Wheat. The Group, centered in the Department of Quantitative Methods, is both interdepartmental and interdisciplinary with representatives from accounting, economics, finance, insurance, marketing, personnel management, and production management.

The Group decided to program the game in BASIC so that modules could easily be merged with the executive routine, and because of the time-sharing capability and widespread availability of the language. The Group then made two crucial decisions; the first version of the game was to include only relatively simple modules for each subarea; and development of more sophisticated modules would be accomplished simultaneously with the programming, debugging, and parameterization of the simplistic version of the game.

Various tasks were allocated to each member of the Group. The development of a rough flowchart of the executive routine was assigned to the Group member with the most gaming experience. Preparation of rough flowcharts for the individual modules was assigned on a one-for-one basis to Group members with expertise in the specific areas. All rough flowcharts were funnelled to one Group member for refinement and logic review while another Group member translated all flowcharts to BASIC and stored the program on the computer. Debugging was handled by a team of three, composed of the Group coordinator, flowcharter and programmer. Parameterization was handled by the group economist. Testing is taking place in two phases as additional features are added. First, the members of the Group play the game and suggest possible modifications. Second, the game is tested in a graduate class at Georgia State University.

At this writing (October, 1972), a great deal of work remains to be done to develop a game capable of supporting a curriculum such as that discussed below. Nevertheless, the authors feel that a substantial beginning has been made. The executive routine, which embodies the basic environmental model, is running reliably on the GSU UNIVAC 7 as are the initialization and output programs. These functions have been deliberately separated, due to the relatively small size limit frequently imposed on BASIC programs, in order that space be available for merging a number of modules simultaneously. (See Charts I and II.)

These routines incorporate a market of a fairly high order of complexity (as compared with existing marketing games),[6] a production process of quite moderate complexity[7], financial decisions of a rudimentary sort[8], and fairly detailed accounting reports[9]. Additionally, some modules have been developed and tested. These include modules for Research and Development, Marketing Research, Personnel Evaluation and Fixed Asset Acquisition (equipment replacement/plant expansion). A financial accounting module which will permit examining the effects of a vast variety of reporting procedures on accounting information is nearly ready. Work has begun on a module to expand the scope of financial decision-making. Personnel have been assigned to modules at higher complexity levels in both marketing and production.

In a related project, the existing programs have been class tested by Geoffrey Churchill and Sandra Feldt, with a view to implementation of the game in what will be described below as the "Early" core. (Note that this does <u>not</u> presuppose implementation of an entire game-based curriculum. This course is presently based on an excellent game[10] but one designed for MBA use.) Despite break-in problems of a normal sort, it is fair to comment that initial expectations appear to be met; students did grasp for models as a satisfying way of bringing order out of chaos.

PROPOSED CURRICULUM

The proposed curriculum consists of three major components: an "Early" Core, electives, and a "Late" core. Chart III illustrates the precedence relationships between the three components of the program.

<u>"Early" Core</u>

In the "Early" core, the student is introduced to the game, remote terminal time-sharing, system concepts, basic modelling in a dynamic environment, and canned programs. After a preliminary introduction to the game, the student is required to play a moderately complex version of the game with a relatively fast rate of decision making. The anticipated result is im-

CHART I

GAME PREPARATION FOR COURSE USE

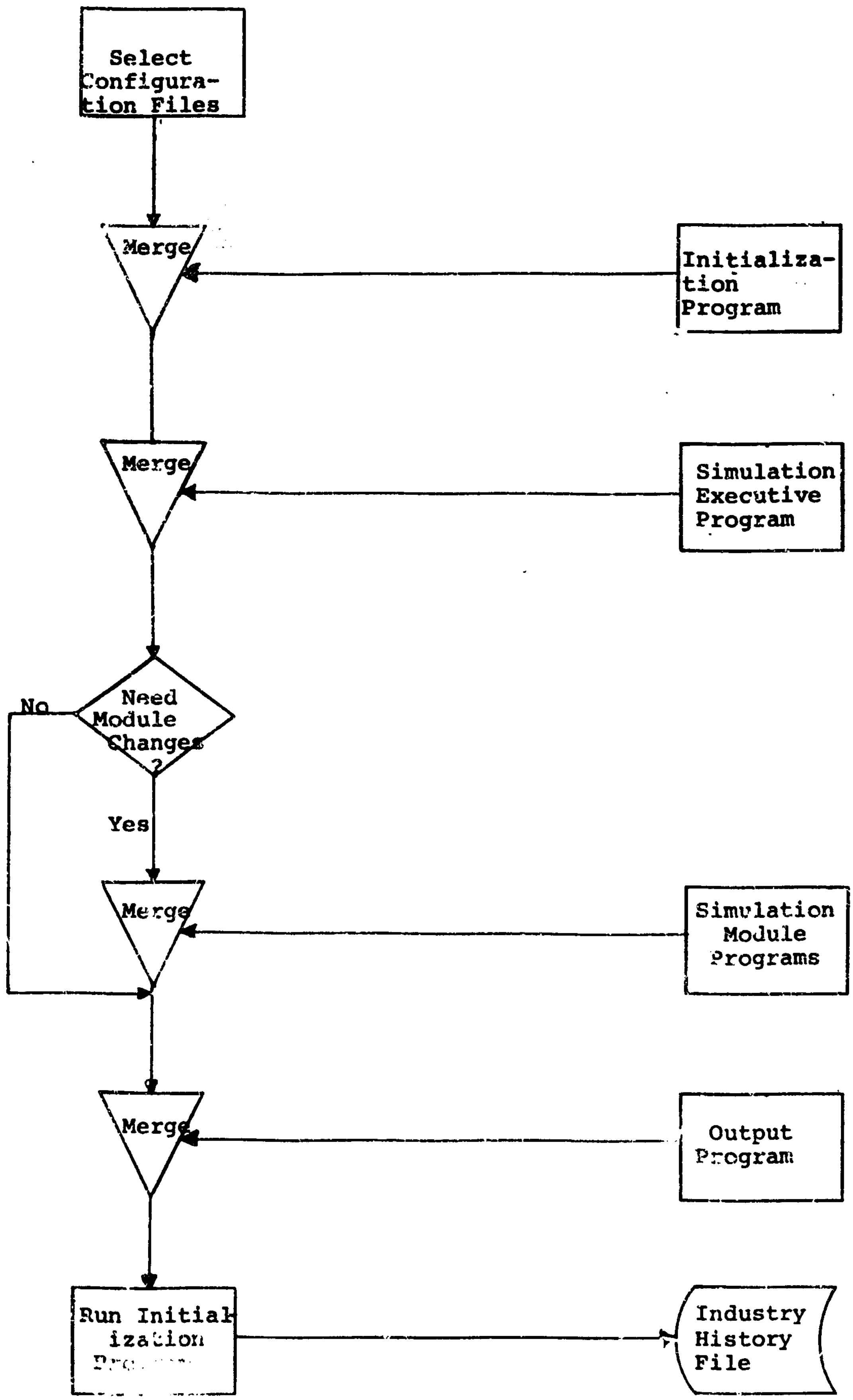
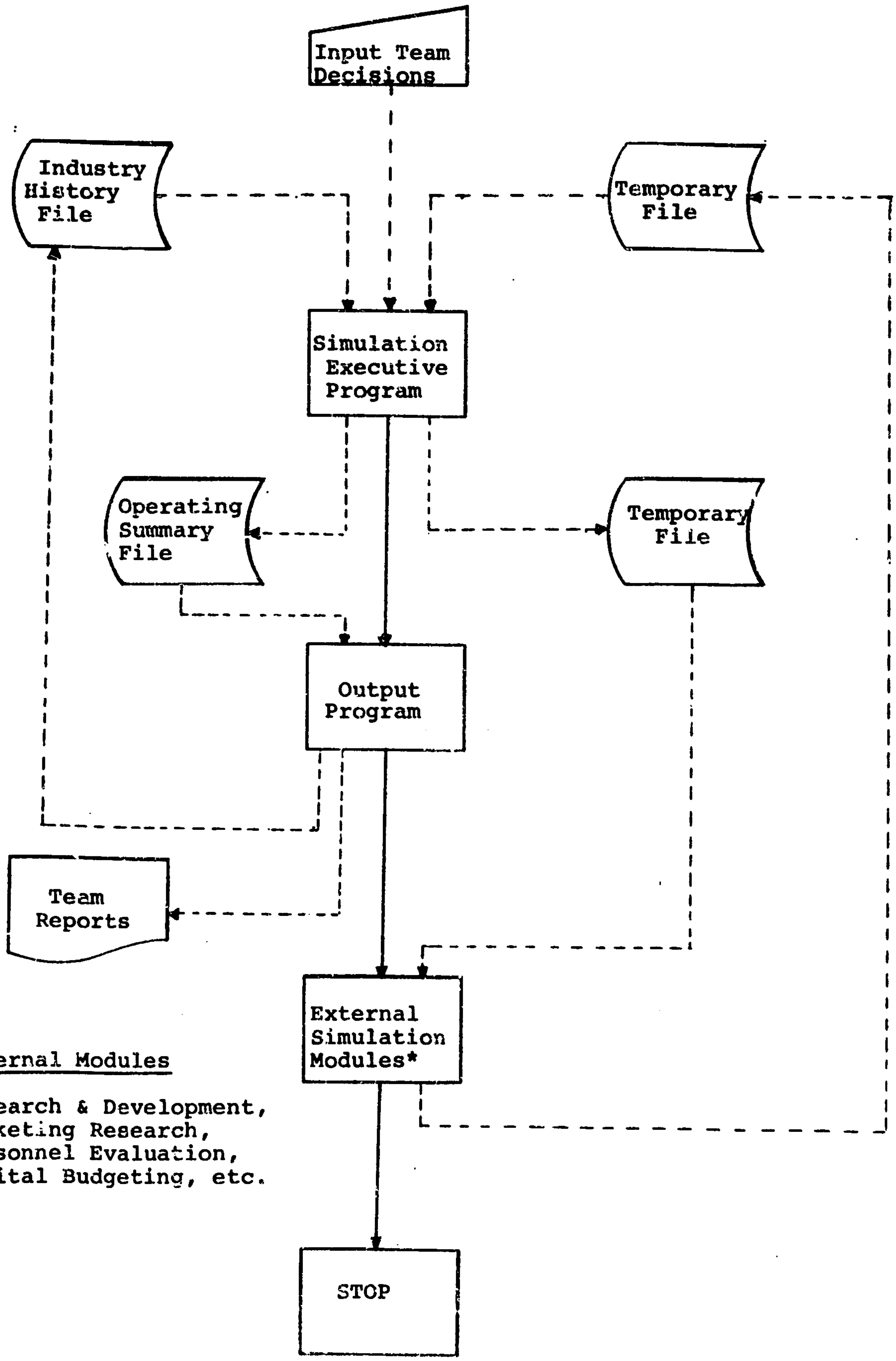


CHART II

SINGLE DECISION PERIOD SIMULATION

GAME OPERATION



* External Modules

Research & Development,
Marketing Research,
Personnel Evaluation,
Capital Budgeting, etc.

mediate chaos. The student is next introduced to some basic quantitative models, which will hopefully bring order out of the chaos.

These basic models include forecasting, cash flow, regression, inventory and linear programming. Each model is introduced in a survey fashion; the canned programs available for them are presented and ways in which they can be used to provide information for decision-making are presented. Students are expected to adapt these models to their needs in the game context, thus getting practice in all phases of Decision Science: observation, problem identification, description of relevant relationships, experimental investigation, interpretation of experimental results, and translation of information into effective action[11].

Before a student uses any model for decision-making, he is required to present a proposal that the model be built to a management committee consisting of students from the "Late" core for their criticism and evaluation. After he has his proposal approved, he is required to file an implementation report.

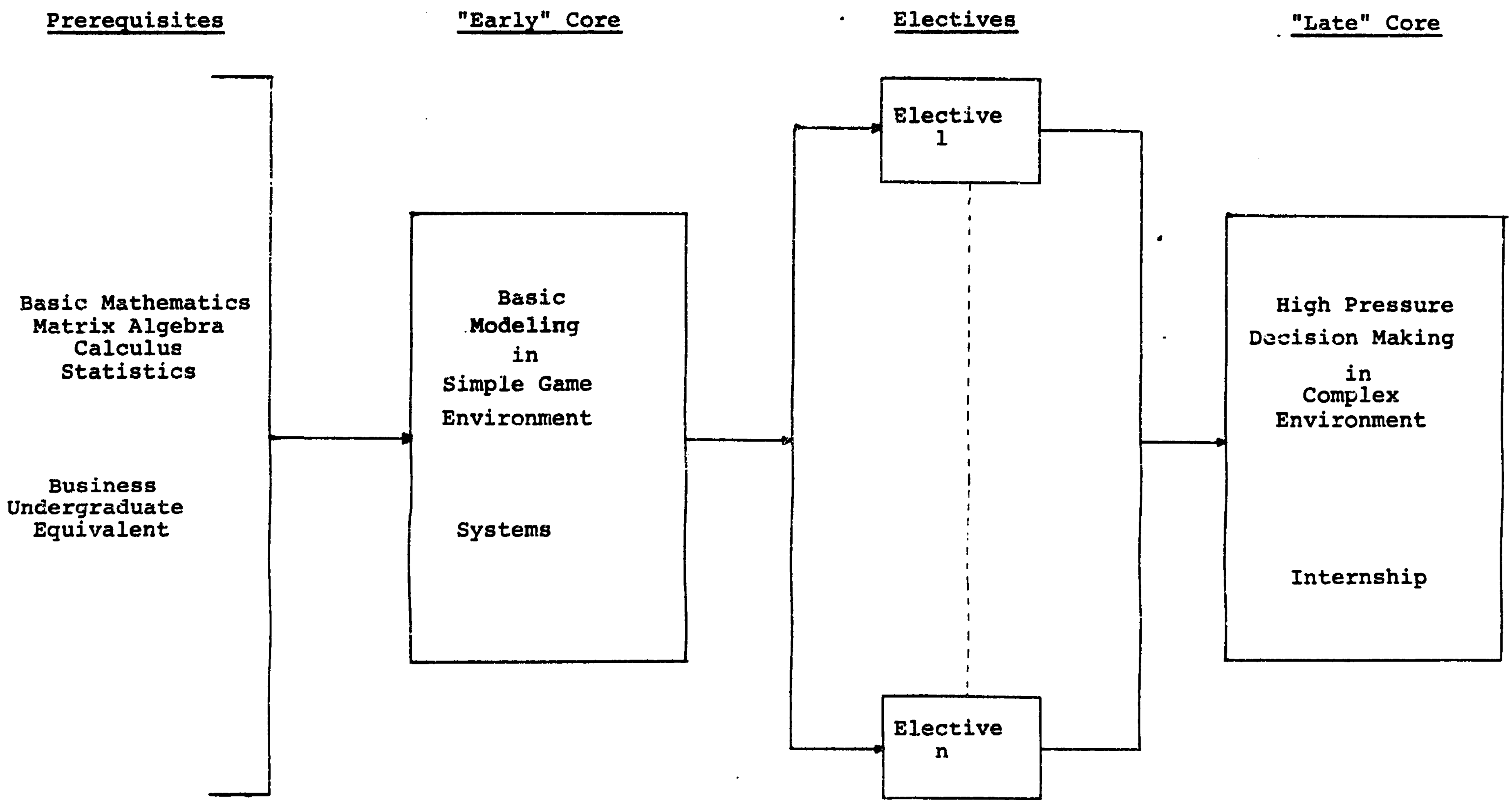
The systems courses in the "Early" core have three objectives. They are expected to enable the student to develop a view of the organization as a system and to recognize and understand its information supplying and suppressing characteristics. A simpler version of the game is used which reports only financial statistics and allows for the expansion of a product line. Students are required to design their own information systems for decision making purposes and to trace the systemic implications of product line expansion from the opening of a research and development facility to product maturity. "Late" core students are again used to criticize information systems designs and suggest revisions.

Elective Courses

These courses are more nearly comparable with currently existing Decision Science courses than are either the "Early" or "Late" core. Still, there are substantial differences. The objectives of these courses include expanding and intensifying the students' modelling capability; indoctrinating the students with a feel for data problems; developing student understanding of the non-independence of quantitative techniques; acquainting the students with the more subtle capabilities and limitations of models; improving the students' understanding and appreciation of sensitivity analysis; and bridging the gap

CHART III

DECISION SCIENCE CURRICULUM



between model solution and decision making.

Course construction to accomplish these objectives is difficult but possible. Lectures can be developed which include a solid theoretical approach through logic and pictures, while escaping the mathematical derivation-theorem proving time sink. Situational problems can be utilized which require ingenious parameter development and allow for prediction of results of decisions. Students can be introduced to canned programs which can be used via remote terminal time-sharing to facilitate any required computation. Available practical computational algorithms should be reviewed along with sources and special features of different packages.

Here, too, the game has a very definite role. It can be used in the appropriate configuration for each course to demonstrate and provide specific course related situations where particular techniques are applicable. In general, however, the game would be incidental to, rather than dominant in, elective courses.

At this point, perhaps some examples are in order. A game configuration which required product mix, transfer pricing, transportation, warehousing, and aggregate scheduling decisions would provide an excellent environment for the introduction of mathematical programming. A configuration which required inventory, cash flow and product line expansion decisions would provide an equally good environment for the introduction of simulation. And what better environment in which to introduce multivariate statistics than one which required pricing decisions and forecasts?

"Late" Core

These courses are designed to provide the transition from student to decision scientist. The first of the "Late" core courses would involve full-scale use of the game with every compatible option present. Students would be required to perform and report to a management committee on major studies of topics such as the automation of routine decisions and the upgrading of return on investment. These groups would also be required to investigate the feasibility of, institute where indicated, and review plant expansion decisions, new product introductions, competitor acquisition decisions, and other decisions of major strategic impact.

The final course in the curriculum would require each student to serve an internship with a local business. During this internship, he would be required to choose a "real" problem, use the decision science approach to solving the problem and present his project in management recommendation form to a committee composed of members of the Decision Science faculty and a representative of the firm where he interns. The student's only other responsibility during the period would be to serve on management committees for "Early" core courses. This feature of the curriculum would complete the student's transition from student to decision scientist and would provide him with a brief but tantalizing view of the other end of the decision making spectrum.

CONCLUSIONS

Progress in the direction the authors have suggested here is highly desirable, but should not be rushed. It was probably the undue haste of various schools in entering the quantitative decision making arena that resulted in the "sophisticated theoretical modeler" phenomenon alluded to in the first paragraph. The game with all the requisite characteristics outlined herein is essential to the success of a curriculum such as the one proposed in this paper.

To the authors' knowledge, an appropriate game does not currently exist[12]. The Operational Gaming Group at Georgia State University has one partially completed. If an existing game with the requisite characteristics has been overlooked, the authors would appreciate any available information on it.

ENDNOTES

[1]Halbrecht Associates, Inc., "Industry's Changing Personnel Specifications for Operations Research Positions," Washington, n.d.

[2]Naturally, there are exceptions to this generalization, such as those people who successfully move into line management.

[3]This claim presupposes the availability of time-sharing remote terminals and canned programs for student use. The contention is based on the use of the game as a learning vehicle rather than as a teaching medium.

[4]See for example, Brian Schott and Arthur C. Nichols, "The Use of a Business Simulation Game in an MBA Core Course in Quantitative Methods," in Laboratories for Training and Development of Executives and Administrators, Oklahoma Christian College, Oklahoma City, 1971.

[5]Edwin L. Heard and Geoffrey Churchill, "Operational Gaming Group Formed at Georgia State," Simulation/Gaming/News, Vol. 1, No. 2, May, 1972.

[6]For comparison, see Ralph L. Day,

Marketing in Action (rev. ed., Homewood, Illinois: Richard D. Irwin, 1968).

[7]For comparison, see Geoffrey Churchill, JØBLØT (New York: Macmillan, 1970.

[8]For comparison, see Paul S. Greenlaw and M. William Frey, FINANSIM (Scranton, Pennsylvania: International Textbook Company, 1967).

[9]For comparison, see Bill R. Darden and William H. Lucas, The Decision Making Game (New York: Appleton-Century-Crofts, 1969).

[10]Arthur C. Nichols and Brian Schott, SIM[Q]; A Business Simulation Game for Decision Science Students (Dubuque, Iowa: Kendall/Hunt, 1972).

[11]See Ronald A. Howard, "Management Science Education: Nature and Nurture", in Management Science, Vol. 17, No. 2, October, 1970. Howard suggests that the course program should include as key elements of study uncertainty, complexity, dynamic effects, economics, optimization, modeling and computer analysis, and behavioral science.

[12]Thanks to an un-named reviewer, we have discovered that groups at Wake Forést and Carnegie Mellon are developing business games which allow for the sequential introduction of decision areas. We understand that these games would, in effect, provide two levels of complexity for each decision area, i.e. each decision area is either there or it is not.