OPEN SYSTEM SIMULATIONS AND SIMULATION BASED RESEARCH[1]

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ABSTRACT

Most simulation efforts have had a pedagogical focus. The issue has been a concern with how to more fully integrate simulation exercises and traditional coursework with essentially closed system games. In the future, however, the focus of attention can include a wide range of research topics by experimenting with open system games. These exercises are likely to be based upon emerging rather than preprogrammed computer routines including, among other conditions, (1) market algorithms that are not programmed in advance, and (2) high degrees of administrator participation. The research topics can include decision making patterns, technological innovation, and high technology in planned and collaborative as well as competitive environments.

INTRODUCTION

Routine, almost casual reviews of the simulation literature lead to one overriding question. What is required to integrate more fully simulation exercises and traditional coursework?

As usual, opinions vary when giving an answer. On one hand, Itan expanded role for business simulation games is hindered by a lack of empirical support concerning the game's ability to address theoretical concepts responsibly" [2]. On the other, "those things that people learn beyond the material of the game tend to be largely unmeasurable" [1].

BASIC ASSUMPTIONS

For purposes of this paper, a different point of view will be adopted. That is, this question is no longer the central issue.

Two suppositions underlie this statement. First, regarding the day-to-day integration problems with simulations and other coursework, it is assumed that simulation technologies will have a far greater effect on what happens in classrooms than pedagogical sciences will have on simulations. This perhaps nonintuitive notion, that technology drives science more than science drives technology, is a well-known result of technological innovation research [6]. In other words, simulations and related computer technologies will assume an ever increasing importance in the classroom. The handwriting is already on the walls but further development of this topic is an issue for another paper.

Second, the real problem with simulation exercises is that they are closed systems. In particular, policy simulations provide students with an opportunity to deal with the fundamental interrelatedness of several business functions, but they do so in a fashion that is unique to the algorithms contained in the specific game. Policy simulations are "wired," and there is little opportunity for participants to act upon rather than just react to the preset macroeconomic parameters and commodity demand functions. While it is true that the participants' collective decisions can counteract basic trend and demand conditions, their effects still lie within limits set by the established algorithms. Unlike real general managers, they do not create a competitive environment within a basically open system.

EXPERIENTIAL BACKGROUND

This disposition, of course, reflects something other than casual observation. It relies on more than ten years of actual classroom experience with policy simulations. The games used range from an early microcomputer model [3] to one of the most complex mainframe applications [7]. In addition, the students involved range from undergraduate business majors to MBAs and practicing executives from the United States, Western Europe, Japan, and Southeast Asia. A list of the simulations employed is shown in Table 1.

This experience has been opportunistic because the search for appropriate packages has been limited to the ones made available by colleagues and publishers. No systematic evaluation of alternatives was attempted. Furthermore, the approach was nonstructured because the implementation and evaluation procedures used for each simulation, with few exceptions, were the ones provided by the authors.

On the other hand, the student evaluations were generally positive with executives expressing the highest degree of satisfaction and undergraduates being the least satisfied. In other words, the degree to which students accepted the various simulations as a learning exercise appeared to show a positive correlation with age.

All of these disclaimers, however, are irrelevant as far as this paper is concerned. The key point is that in almost all cases, students learned how to "game-the-game." In general, the sequence of events followed this pattern:

1. All students experienced confusion over the rules of the simulation and how to actually execute a set of decisions.
2. Good students resolved the confusion, built cash flow models, and began to understand the simulation prescribed interrelatedness rules among marketing, production, finance, and overall economic functions.

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TABLE 1
SIMULATION EXPERIENCE BASE

Simulation	Authors	Period of Use	Type of Student
International Operations Simulation	Hans B. Thorelli & Robert L. Graves	1983 -	MBA, Executive
Manager	Jerald R. Smith	1985 -	Undergraduate
MICROMATIC	Timothy W. Scott & Alonzo J. Strickland III	1986 -	MBA
Planets II (CAPTERTSIM)	U.S. Army Logistics Command	1982 - 1983	MBA
TASK	Alan J. Rowe	1980 -	Undergraduate
The Executive Simulation	Bernard Keys & Howard Leftwich	1985 -	Undergraduate
The Multinational Management Game	Alfred G. Edge & Bernard Keys & William E. Remus	1981 -	Undergraduate, Executive
Top Management Decision Game	Joseph Nordstrom	1979 -	Executive
USC Management Strategy Simulation	Paul A. Gruendemann et al.	1972 - 1986	MBA

3. Average students witnessed the success of good ones, copied their procedures, and became more competitive.
4. Most students now "knew-the-rules" and played accordingly.
5. Poor students complained.
6. Minor changes in team standings occurred as students honed their gaming techniques.
7. Overall, there was no obvious correlation (based upon experience, not data) between policy simulation performance and performance on case analyses, industry analyses, and specific company analyses.

Actually, more work needs to be done on this last point since some of the relevant data has been collected in a more systematic fashion during the past few years. But, this is a subject for another paper. The key issue is that the first six findings are fairly consistent over the ten-year period, three types of students, and different cultures. In fact, they are remarkably consistent, including a reasonable degree of satisfaction over all students even though the older one expressed more interest.

Said in another way, further empirical investigations seem destined to repeat the range of conclusions cited in the opening paragraphs. Short term, cross sectional studies only reveal that this simulation or that one produces superior or inferior learning on one set of concepts or another. They do not yield the long term results just noted.

THE ROAD AHEAD

Nevertheless, assuming that these experiences are common among experienced simulation users, two important conclusions follow.

1. A relatively common technology, closed system simulations, produces common results in the long run, however variable the short run statistics may be.
2. Other simulation technologies, for example, open systems, need to be developed if their full potential is to be exploited.

Open System Simulations

What then is meant by an open system simulation? Basically, two main ideas are implied.

1. The algorithms that determine the simulation outcomes, however flexible in regard to participant inputs, are not programmed in advance of play. They emerge as a result of decision making.
2. Simulation administrators become one of the participants rather than acting as referees over participant actions.

Equally important under these conditions, a simulation becomes a research as well as a pedagogical vehicle. It can be used to study:

1. Market structure and dynamics in an unconstrained rather than algorithmically circumscribed environment.
2. Decision making that leads to the creation of markets.
3. Collaborative or collective as well as competitive strategies.
4. Leadership tactics in a laboratory (classroom or experiential learning center) that approximate actual business conditions.
5. Group structure and dynamics as competitive conditions change.

6. Decision making in environments where competition is conspicuously absent, such as large scale projects, again using the classroom or experiential learning center as a laboratory.

7. Resource allocation decisions in competitive environments that are threatened with new entrants, a feature absent from most simulations.

8. True product development and market introduction tactics beyond a known set of predetermined simulation alternatives.

9. Service industry rather than product industry phenomena.

In fact, the list of possibilities is endless, limited only by imagination. Nevertheless, the basic idea is simple. To repeat, simulations have at least as much potential as research vehicles as they do in pedagogical endeavors. One way to summarize this potential is shown in Table 2.

The two key dimensions in Table 2 are the simulation environment and the phenomena under consideration. Pairing them, or considering the various combinations, suggests a large number of research possibilities for open system simulations. For example, very little is known about decision making patterns in planned environments such as those common to large scale projects [51. A similar statement can be made regarding decision making in collaborative environments such as those found in joint ventures. New entry threats in competitive environments have already been mentioned.

Moving towards more behavioral issues, leadership styles and group dynamics are obvious phenomena for open systems study. Much of the current literature in these areas depends upon highly constrained laboratory studies or public phenomena that are difficult to measure. An open system simulation would have the advantages of both approaches and minimize the disadvantages. In short, a simulation that allows behavior to emerge has the features of ordinary social behavior, but it does so along various prescribed dimensions similar to a laboratory experiment. Thus, the measurement of social phenomena is possible without overly constraining it.

Other phenomena of interest would include technological (product and process) innovation and high technology [4]. The research issues in this case would include resource allocation patterns and risk taking behavior in different kinds of open system environments.

As already mentioned, the list is endless. At a minimum, the three types of environments shown in Table 2 are only a beginning, as are the areas suggested for study. Once open system simulations can be made available, something like Table 2 can be expanded at will.

The Immediate Questions

Of course, open systems will not become available overnight. Just like the suggested issues that can be researched with them, they comprise an entire set of research issues. At the risk of oversimplification, however, three key considerations are paramount:

1. Are open system simulations comparable to artificial intelligence, expert systems, and decision support systems?

2. How would the design of an open system begin?

3. What are the key topics on which an open system should focus?

No doubt, it would be comforting to draw from other research endeavors such as artificial intelligence (Al), expert systems (ES), and decision support systems (DSS) in order to get a fast start on open system simulations. The problem is that none of them meet the necessary criteria even though each may benefit from open system simulation designs.

Al, for example, is an attempt to develop computer hardware and software that learns from experience [81. Such learning may mimic human behavior, be

TABLE 2
SOME EXAMPLES OF SIMULATION BASED RESEARCH PROJECTS

Phenomena	Planned	Collaborative	Competitive
Decision Making Patterns	Large Scale Projects	Joint Venture Management	New Entry Threats
Leadership/Management Styles	Bureaucratic	Political	Strategic
Group Structure/ Dynamics	Power/Affect/Status Structures	Social Roles and Social Systems	Exchange/Reward Patterns
Technological Innovation/High Technology	Resource Allocation Patterns	Risk Taking Behavior	Success/Failure Patterns

superior to it, be altogether different from it, or be some combination of these alternatives. Any one of these results are equally desirable. The idea is to create machines that act intelligently, machines with programs that reprogram themselves based upon experience.

Open systems simulations, however, are qualitatively different. Here the idea is to take intelligent systems, like people, have them create environments that can be recorded in a computer, and study their behavior in the environments that they create. Presumably, any artificially intelligent system could participate in such a game, but Al is a very long way from duplicating even the most primitive human characteristics.

Even more remote, ES does not attempt to approach the basic creativity problem. Like much so-called business policy research, it only tries to duplicate decisions. The basic paradigm has three steps, however complicated the intervening machinations:
(1) program an expert's decision rules until a computer reaches the same decisions as the expert did in the past, (2) test the decision rules on new data, and (3) recycle until the program and the expert reach the same decisions on further new data. There is not much environmental creativity in the process.

Most remote, DSS is not intended to create an environment. Its key and very useful purpose is to help a decision maker model an environment. Such models help in the solution of accounts receivable, inventory, cost of capital, and similar decisions, but they only reflect an environment. At best, they help in resource allocation decisions; at worst, they are super spreadsheets for a dull afternoon's entertainment.

All of this argumentation and justification, of course, is preliminary to the issue of how to begin research on open system simulation designs, let alone applying them to relevant research questions. It simply is not an easy question to answer. However, an examination of standard simulation design routines suggests an important partial answer.

That is, most simulations are developed because someone has an idea about how to program:

1. An accounting sequence from the purchase of raw materials to the sale of finished goods.

2. An interesting demand function that goes beyond prices and advertising to include such factors as R&D, product differentiation, marketing efforts, and various leads and lags in these factors.

3. A special topic such as PERT or product life cycles.

Once programmed, including the basic 90% of the code concerned with accounting for each participant or team's position, the simulation is tested on a sample population, debugged, and retested. Finally, a user's manual is written to convey the necessary operating details to the uninitiated.

Herein lies the problem. The user's manual was not written first.[2] What people are supposed to do when participating in the simulation, playing the game, is decided after the fact of simulation design, not before.

Said in another way, the real purpose of the simulation is decided after the fact of design convenience. Typically, computer coding drives simulations purposes rather than the reverse. Back to the beginning of this paper, it is a small wonder that short term research results lead to equivocal conclusions on simulation usefulness. Simulation purposes, for the most part, are decided by coding convenience rather than pedagogical or conceptual relevance. In short, open systems simulations need to proceed in the reverse order of closed system ones. That is, they need to begin with the user's manual, a statement of what is desired.

What is desired, of course, are basic statements of what needs to happen in an open system simulation. In particular, for policy simulations, answers to the following questions are needed:

1. What kind of decision making behaviors needs to occur and how will they be recorded in a fashion suitable for computer programming?

2. What kinds of information need to be provided to participants prior to the decision making sessions?

3. Can flexible computer routines be written that allow decision process modelling in a matter of minutes rather than days.

4. If the preceding problem can be solved, how can the models applicable to several participants or teams be made interactive?

5. Similar to closed system games, what sort of external constraints are required?

These are tough questions, and answers will not be easy to find. On the other hand, answers need to be found if policy simulation technologies are to get beyond the current closed system limits.

CONCLUSIONS

Another way of looking at open system simulations is as a cross between many of the current activities in experiential laboratories and closed system simulations. Much of what happens in an experiential laboratory is for learning by

observation purposes. Group and interpersonal phenomena such as decision making, role differentiation, and communication can be observed firsthand as a practical test of fundamental motivation and perception theories. Moreover, basic changes, especially in group structures and processes, can be observed as they emerge over time.

On the other hand, policy simulation decisions are usually done in a rather "secret" environment. Participants have to infer from published data what the behavior of competitors means. Nevertheless, they are making their inferences within a well-structured set of algorithms. Their basic structures, unlike the power-affect-status structures in group behavior, do not emerge over time.

What we need is a reasonable combination of the two. The payoff, as argued in this paper, is the

[2] This point of view was contributed by Michael E. Andersen, project research assistant.

development of entirely new research methods and research areas that can be investigated in the simulation mode. Games will always be important as pedagogical tools, they have been for centuries. But they have an equally if not more important role in research.

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