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THE DESIGN AND USE OF GAMING SIMULATION MODELS FOR EDUCATIONAL POLICY-MAKING AND PLANNING

A Qualifying Paper
Submitted by

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There is a great and growing need for the kinds of powers of communication that help a person gain, vicariously, a feeling for the nature of fields too extensive and diverse to be directly experienced. This need is an objective one, an ineluctable concomitant to decision within a highly interconnected biosphere that is beginning to fill up.

Prose and its archetype, the mathematical equation, do not suffice. They offer more specificity within a sharply limited region of discourse than is safe, since the clearly explicit can be so easily mistaken for truth, and the difference can be large when context is slighted. Also, prosaic description has a natural affinity for speciality which is nearly the opposite of the mood within which wholes are to be 'felt.'

One should learn wholes first as one learns first the shape of distant mountains; afterward is soon enough -- and the right time -- for learning separate facts or separate trees and streams. There is therefore, a need for holistic communication that predates and supersedes the special urgency deriving from the macro-problem of these times. For any new excursion into understanding, we should start first with the sweeping comprehensions and then seek to learn, or teach, component facts. The route of science, prosaic exposition, and academic speciality has normally been the opposite. (Rhyne, 1974: 92)

Purpose of the Paper

This study will analyze the design and use of a planning technique that incorporates algorithmic as well as heuristic functions, allowing for statistical relevance within a political, social or cultural context. The purpose of this paper is (1) to review the literature and analyze the trend towards the use of computer technology within gaming simulation as a viable and valid feature of the policy and planning process in education and human resource development and (2) to draw implications from present experience with gaming simulation to its use in educational policy making. It is not intended that this will be an exhaustive study of gaming literature, rather it will focus more specifically on the interactive use of computer technology within simulation gaming and trace implications for education planning within the context of international development.

Structure of the Paper

This paper is divided into five parts. Part I contains a brief introduction to the subject of gaming simulation, identifying its place within the planning and policy context. Part II begins with a review of the history and terminology of gaming simulation and continues on to present a discussion of the uses of gaming simulation in policy and planning; a taxonomy of forecasting and planning methods is also presented in this section. Part III presents a discussion of formal game theory, the relationship between game theory and gaming. A typology of games and a computer simulation typology discussing four perspectives on gaming simulation and participant interaction are also presented. Part IV presents an assessment of three games for their use in educational policy making and planning. Part V concludes the paper.

PART I:

GAMING SIMULATION AND THE POLICY AND PLANNING CONTEXT

Introduction

The rapid escalation of economic, scientific and social development since World War II has brought about radical change throughout the world. In particular, large demographic changes as well as enormous technological advances have occurred in communication, transportation, energy and food production. As a result, policy makers, planners and managers everywhere must deal with highly complex issues within societies which have grown increasingly pluralistic. Accordingly, the methods used in policy making and planning have begun to include simulation models that represent the complex character of various problems with which decision makers are confronted while allowing for multi-actor participation within pluralistic social and political environments.

The Planning and Policy Making Context

Simulation models used for systematic planning and policy making in education systems are classified into two broad groups called *algorithmic* and *heuristic* (Davis, 1980). Algorithmic or mathematical models are quantitative methods of analysis that use set procedures to produce computable solutions. Heuristic models are qualitative methods of analysis that have no set procedures and are used to stimulate an exploratory process (Davis, 1980). Algorithmic models are most effectively used when the relationships among factors can be expressed in arithmetic or algebraic form in the analysis of specific data. However, the use of algorithmic models is often constrained by

limited data. This is particularly the case in non-industrialized, or less developed countries (LDCs) of the Third World where data either does not exist or is statistically unreliable. In addition, planning and policy making deals with unspecific data of a political, social or cultural nature that are not easily expressed by algorithmic models (Davis, 1980; McGinn, 1980; Warwick, 1980). Heuristic models, however, can simulate the non-quantifiable, qualitative data expressing the political, social or cultural characteristics of complex systems.

Gaming simulation is a modeling technique that combines heuristics and algorithms. The application of gaming simulation to policy development and planning processes combines qualitative and quantitative methods of analysis (Greenblat, 1987; Gray and Borovits, 1986; Klabbers, 1987; Shubik, 1983). The *gaming* component of a gaming simulation model is useful (1) to exploratory studies in which human responses or interactions are not predictable or in which humans are part of the process being investigated (Duke, 1974; Abt, 1974); (2) to elicit the active involvement of all participants (Boocock and Schild, 1968; Greenblat and Duke, 1975 and 1981; Shubik, 1975); and (3) to assist participants in understanding the nature of situations (Rhyne, 1974; Stahl, 1983; Greenblat and Duke, 1975 and 1981; Shubik, 1975).

The *simulation* component of a gaming simulation model is useful in modeling human decision making inputs that occur at the beginning or end of the process (or at intermittent points in between), and for situations in which the dimensionality of the problem is relatively small (Gray and Borovits, 1986).

PART II:

HISTORY AND USES OF GAMING SIMULATION

Historical Context

The use of gaming simulation to reflect problems of the real world goes as far back as 3000 B.C. to the Chinese game of Wei-Hai - currently known by the Japanese name of Go. Elements of game theory which represent the beginnings of war-gaming have been found in the 5th century B.C. writings of the Chinese general Sun Tsu (Shubik, 1983). In the 18th century elaborate chess-like games with 1666 squares and pieces representing batteries of seige guns, battalions of fusiliers and squadrons of dragoons were used in England (Kibbee et al., 1961). In Germany the "New Kriegspiel" was introduced in 1798 which replaced the earlier English game boards with maps. The game involved hundreds of rules and thousands of pieces and was used to train the Prussian military (Thomas, 1957). After World War II, large-scale military games were developed for use on mainframe computers (Shubik, 1975a, 1975b; Luce and Raiffa, 1967; Von Neumann and Morgenstern, 1947).

The first games used in planning, policy making and in education were an outgrowth of war games. Early management games were used to simulate the economic environment via computer-generated mathematical models (Ricciardi et al., 1957). During the 1960s, gaming simulation was used broadly as a teaching tool in colleges and universities as well as in elementary and secondary school classrooms (Boocock, 1968; Abt, 1970; Greenblat and Duke, 1981). During the past two decades, with the rapid development of computer technology, gaming simulation has been put to use most notably within the field of urban planning (Duke, 1981; Elgood, 1984;

Stahl, 1984). Since 1980, there has been a dramatic increase in the use of gaming simulation in education, planning and public policy (Gray and Borovits, 1986; Meadows, 1985; Greenblat, 1987; Klabbers, et al., 1980). The reasons for this trend include:

1. The introduction of microcomputers that facilitate the simulation process (Meadows, 1985; Klabbers, 1987);

2. The introduction of software that allows for proper reduction of data for public policy issues (Duke, 1981);

3. Increased awareness of the interface between qualitative issues of public officials and the quantitative data gathered by academic researchers (Duke, 1981);

4. The growing need for holistic processes of communication that helps to relate the factors in a complex set of policy issues (Rhyne, 1974);

5. Increased user/computer interaction (Cassidy, 1986).

Gaming Simulation Terminology

The terminology used in gaming simulation literature refers to three distinct topics which are interrelated but very different. They are: simulation, gaming and game theory.

Simulation is a dynamic representation of reality that uses substitute components and relationships to replace their real or hypothetical counterparts. A simulation may be an abstracted, simplified, or accelerated model of reality (Jones, 1986), the key features of which are identified and ordered in a way that reflects the system in the real world. "Pure" simulation of human or social systems assumes that individual or aggregate human behavior does not change once the basic traits have been established

and that the system is well defined (Klabbers, 1987). A pure simulation is defined as a model that is represented entirely by mathematical equations. Simulations can be made of technological or social systems. There are three modes of simulation: (1) manual simulation requires no computer involvement; (2) machine simulations run entirely on the computer; (3) man-machine simulations are those in which interaction takes place between the computer and the human participant at the beginning or the end of a simulation (Inbar and Stoll, 1972). As it is practiced today, simulation is more computer-oriented than people-oriented. A computer can be used to make decisions, take actions and produce the results of other actions and consequences of decisions (Gibbs, 1974b; Greenblat, 1981; Shubik, 1983).

Gaming is a teaching and experimental method which is carried out by cooperating or competing decision-makers seeking to achieve their objectives according to a set of rules. In contrast to simulation, gaming is people oriented; the individual plays a central role in any variety(Gibbs, 1974; Greenblat, 1981; Shubik, 1984). Gaming can be used in situations where problems or goals are loosely defined and where it is understood that human intervention is inherent to the handling of problems and that human behavior changes over time (Klabbers, 1987; Shubik, 1984). The primary characteristics of games are that the participants have (1) roles to play, (2) goals to achieve, (3) activities to perform, (4) constraints, and (5) positive or negative payoffs.

In addition to these distinctions in terminology, theorists and practitioners have associated simulation and gaming with two academic realms. Gaming is described as closely connected with the behavioral sciences (Shubik, 1984) or, in general, the social sciences (Klabbers, 1987),

while simulation is more firmly intertwined with econometric or mathematical sciences. Klabbers (1987) suggests several other distinctions between simulation and gaming: simulation relies on statistical representation of data based on universal definitions for units of analysis, that is objective, reliable, predicatable and controlable; gaming, on the other hand, relies more on non-statistical representation of data that allows for subjectivity and change, is not necessarily predictable and is concerned with meaning rather than control.

> Simulation is predominantly concerned with description of general characteristics and ultimately control of reality. Gaming, on the other hand, is more receptive to making sense of reality and to meaning processing, that is, communication between human beings (Klabbers, 1987: p. 271).

The distinctions made by Klabbers and Shubik are summarized below.

Table 1: Summary of Gaming Simulation General Characteristics

Dimensions of Contrast	Simulation	Gaming
Academic realm	econometric/ mathematical sciences	behavioral/ social sciences
Data representation	quantitative	qualitative
Kowledge of the system	complete	incomplete
System definition	clearly defined	vaguely defined
Perceptions	perfect	imperfect
System behavior	set	subject to change
Human behavior	invariable	variable
Concern for reality	control of reality	meaning of reality
Concern for reliability	objective, predictable	subjective, not predictable
Concern for validity	based on universal definitions	based on context, individualistic

Gaming simulation (This term often is used alternately and interchangeably with "simulation-games" or "game-simulations.") is a hybrid that contains characteristics of both gaming and simulation where game activities are placed in simulated contexts. A gaming simulation will pattern the *gaming* roles, goals, activities, constraints and consequences, and their relationships, from real life to *simulate* elements in the real world system (Gibbs, 1975; Jones, 1986; Greenblat, 1987). The specific distinctions made by Klabbers and Shubik between the approaches made by two different academic cultures are merging because "microcomputer configurations are becoming more and more transparent for the average user to play with (Klabbers, 1987: p. 271).

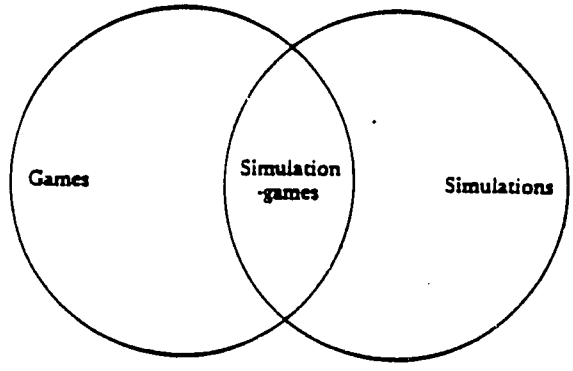

Figure 1: The relationship between gaming, simulation and gaming simulation (Gibbs, 1975:8).

The application of gaming simulation to planning and policy remained in the domain of military strategists until the end of World War II. Teachers in business schools and later, political scientists, adopted the technique and incorporated it into the curricula, followed by faculty in schools of education and then the other social sciences. The primary use of gaming simulation for the past 25 years has been in the academic context. Its use in the public policy and planning sector has been limited.

An ERIC Bibliography by Cruickshank (1979) lists over 2,000 titles in simulation and gaming. The bibliography is divided into 63 categories. In the category of educational planning there are 54 entries, however only 10 percent include gaming. Instead, the vast majority are computerized simulation models used for cost effectiveness, financing programs, demographic and enrollment projections, facilities capacity and other projections. These data are consistent with more recent observations made by others (Duke, 1981; Elgood, 1984; Stahl, 1983).

Although there is a dearth of games available for examination in education policy making and planning, the trend will be toward greater usage in the future if the numbers of business games currently in use in academia and business serves, as it has in the past as indicated above, as an indicator. Faria (1987) estimates that approximately 1900 four-year schools employ games in about 3280 of their courses. Most of the games used at the American Assembly of Collegiate Schools of Business (AACSB) surveyed by Faria were computer-based and were used in either business policy or marketing courses. A survey of American corporations and businesses showed that 5000 companies were using business games for their own training and development purposes (Faria, 1987). Another survey of management development consultants and their firms showed that they were supplying gaming simulations to some 6100 clients and that an increased use was expected in the future. These growth and usage rates were based on the market's experience with mainframe games that were far more difficult to install and operate than the new PC-based games that will be more easily employed in the future.

The initial use of mainframe computer technology in the 1950s and 1960s involved large data banks. Duke points out that the use of computers in this way were failures for four reasons, which he summarizes as follows:

1. They were premature in that no rational, coherent theory existed to guide their articulation and development;

2. No models, simulations or similar processes were in existence which could benefit from the data;

3. No suitable hardware and/or software existed for the proper reduction of this data for public policy issues;

4. There was no experience with the communication interface between public officials and quantitative data of this type.

Models and simulations for urban management purposes developed at the same time as data banks. Large traffic models, for instance, prompted the development of the Interstate Highway System. These models were further developed and sold to cities for implementation in a variety of areas. The implementation success rate here was also poor for several reasons.

> First, there was a lack of coherent and tested theory to guide their development. As a consequence they proceeded on an ad hoc and experimental basis. As these model sets emerged their defined data needs were, in many cases, not met by the existing data banks which had been prepared in an anticipation of the models (the classic "cart before the horse" situation) and the result was often that data were pieced together at the last moment in an ad hoc and estimated fashion. These models, in their complexity, quickly outran the available computing power for practical purposes, and they were soon restricted to use by university groups and others who had an interest in their scientific development. *Finally and most significantly, those efforts which did reach some technical success failed almost completely in their public policy mission because politicians put little or no faith in the product.* (Duke, 1981: p.227 with author's italics)

At the local level of policy and planning, several analytical techniques such as critical path network, queuing theory, statistical methods, PERT, systems analysis in several forms, and demographic models have been used with growing success. Duke cites these as important examples since they have been perceived to be most successful at the community level. "One can assume that in the coming decade similar analytic techniques will find their way into the community as each new crop of university students emerges into the working world" (Duke, 1981:228).

Hardware and software are important controlling variables in understanding the impact of science and technology on public policy in the post-World War II period. The development and widescale dissemination and use of microcomputers have further implications for the integration of technology with policy and planning activities. Microcomputers allow for use and accessibility that did not exist earlier. As discussed above, when microcomputers are combined with gaming, it is possible to achieve an environment in which social and political roles are complimented by technological information. In this way, gaming simulation can be used as a communication interface between researchers and technical experts and the policy makers, planners and managers. Gaming simulation thus has the possibility of bridging the communication gap between science and public policy. This communication gap has been severe and flows from several difficulties:

1. The basic objectives of the scientist and the policy maker are very different. The scientist seeks replicable "Truth and the logical pursuit of its consequences. The public policy maker operates in a world of reality and hopes through coalition formation to achieve "the art of the possible."

2. This first characteristic derives in part from a second basic difference. The scientist needs quantifiable, replicable data; the politician works with non-quantifiable, nonreplicable imagery that derives from a political sense.

3. The first two difficulties in turn contribute to a third, which is the impediment of jargon.

4. The scientist and policy maker operate on different time horizons. The scientist focuses on horizons appropriate to scientific data; the politician focuses on horizons of strictly political significance.

5. The two frequently operate from a different scope or perspective in terms of definition of the problem. There is no inherent reason why micro and macro perception need to be at variance; however, as a practical matter, the scientist and politician are at different ends of the continuum.

6. The two groups operate with conflicting reward structures and peer group imagery. The scientist will tend to be much more concerned with the elegance of the mathematical model while the politician will take a jaundiced view until its pragmatic value in political terms has been revealed (Duke, 1981:234).

The gap, or the "great divide" (Weiss, 1980) between researchers, or knowledge producers, and policy makers, or knowledge users, has been discussed by other social scientists (Weick, 1979; Weiss, 1980; Mitchell, 1980; Klabbers, 1985); Table 2 summarizes the differences perceived.

Table 2: Summary of Perceived Differences Between Science and Public Policy

	Science	Public Policy
Users	Researchers & technical experts	Policy makers, planners managers, public officials
Objectives	Search for replicable truth through logical pursuit	To achieve the "art of the possible" through coalitions
Data used	Quantifiable, replicable empirical	Qualitative, non-replicable imagery derived from a political sense
Time horizon	Appropriate to scientific data	Appropriate to political significance
Language	Scientific jargon	Political jargon
Problem definition	Micro perception	Macro perception
Reward structures & peer group imagery	Elegance of the model	Practicality of model
Knowledge	Active producers of knowledge	Passive users of knowledge

In the rational model research is conducted with the assumption that there is a causal linear path leading directly from the knowledge producers to the knowledge users who implement policies according to a well thought out progression of events leading to a specific goal. However, Weiss (1980) describes a complex model of diffuse policy decisions where research knowledge is transmitted and absorbed through diffuse, informal routes. Research knowledge is transmitted through discussions, meetings and casual readings. In such a world a linear sequence from research to policy to implementation does not exist. Rather, Weiss says, research provides a background of data, empirical generalizations, and ideas that affect the way that policy-makers think about problems. Weiss calls this the 'enlightenment function' of research.

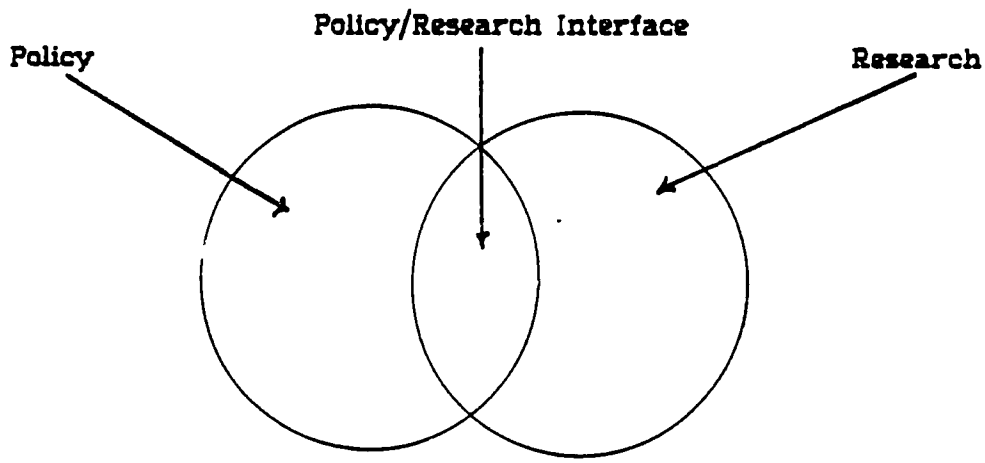

Figure 2: The interface between policy and research

Thus, policy-makers use heuristic strategies that include not only research results based on empirical data, but also social knowledge and practical experience. The image of the traditional linear models that depict the researcher as active transmitter and the policy maker as passive is changed to another image where the user is central to the model and is an active, inquiring, problem-solving participant. The process of assimilation of results of research by the public policy-making system described by Weiss is far more complex and diffuse than is commonly described in the academic literature and refutes the model of the decision-making process based on rational theories.

Gaming Simulation and the Policy/Research Interface

With the diffuse model of decision making in mind, and building on the research of others (Weick, 1979; Mitchell, 1980), Klabbers (1985) offers a dynamic, interactive model of the policy-making process. Weick states three processes of organizing behaviour: (1) enactment, (2) selection and (3) retention and Mitchell distinguishes four phases of decision-making. Each stage requires distinctive functions of social science research:

- articulation (enactment), in which social science research serves in the conceptualization of the policy issue and group building within major interest groups.

- aggregation (selection), in which social science knowledge is concerned with problem-solving.

- allocation (retention), in which the main impact of social science is related to evidence assessment and persuasion.

- oversight (feedback retention-enactment), in which social science is involved in evaluation studies and criticism is being mobilized.

Klabbers suggests that, according to place and circumstance, different gaming simulations are appropriate to each phase. For example, at the phase of articulation and conceptualization, a free form game is appropriate as it is "environment rich." Attention is paid to institutional detail, context and to the problem of realistic scenario presentation and it allows participants to supply institutional assumptions. At the aggregation/problem-solving phase and at the allocation/evidence assessment stages, rigid rule games with interactive simulations can be employed. Rigid rule games are useful after articulation has been completed and at the point when definition is clear because they can be employed to reinforce the defined structure. This is based on a theory of social strata described later fon page 17.

As discussed above, research, planning and public policy formation take place in dynamic environments. Klabbers (1984) has described a model coupling the macro-cycle of policy making with phases of the policy making process. As part of the "coupling model" he suggests the use of interactive gaming simulations as analytical instruments and communciation tools.

Based on three basic levels of description of social systems presented by Mesarovic et al. (1970), Klabbers presents a taxonomy of forecasting and planning methods that can be used according to conditions within the planning environment discussed by Trist (1980) and Ackoff (1974). This taxonomy is combined with his idea of a model depicting phases of the policy formulation process.

The Planning Environment

The planning environment is categorized by four types that also represent historical periods in time: (1) a placid random environment; (2) a placid clustered environment; (3) a disturbed reactive environment and (4) a turbulent environment. Each of these four types of planning environments requires different planning methods. Trist suggests that the period of time after post World War II was characterized by a disturbed reactive environment where organizations competed, or reacted to each other for optimal market positions. This historical period gave away to a turbulent environment of uncertainty and change in the early 1970s. Trist links the four environmental types with corresponding ways of planning which he called: (1) inactive, (2) reactive, (3) preactive, and (4) interactive.

Table 3: Historical periods of planning according to Trist (1980)

Environmental Type	Planning Method
Placid, random	Inactive
Placid, clustered	Reactive
Disturbed, reactive	Preactive
Turbulent	Interactive

According to Klabbers, preactive planners were concerned with making blueprints which required a focus on "mechanical" aspects of planning, while interactive planning requires a process of continuous learning, evaluation, and modification, requiring greater focus on "conceptual" aspects of planning. Interactive planning involves parts of social systems as well as the techno-economic aspects. During a period of turmoil (turbulence), traditional structures erode, while new ones still are emerging. During such

a period, the entire fabric of social and societal systems changes rapidly. As a result, planning methods have to be more diversified to be able to include value orientations of social systems (Klabbers, 1985).

It is with this environmental and historical context of planning that Klabbers offers a taxonomy of planning methods.

A Taxonomy of Planning Methods

The taxonomy of planning methods presented in Figure 3 is based on a combination of the three basic strata of social systems distinguished by Mesarovic et al. (1970) and those distinctions generally made in organizational sciences. The three interrelated strata distinguished by Mesarovic are: (1) a norms and value stratum, (2) a decision-making stratum, and (3) a causal stratum. The right side of Figure 3 indicates each of the three stratum from top to bottom and shows the corresponding distinctions made in organizational sciences in parentheses. That is, the norms and values stratum is associated with culture (including norms, values, attitudes, moral), the decision making stratum is associated with structure (vertical and horizontal communication and coordination); and the causal stratum is associated with technology (including the entire complex of work procedures).

The taxonomy is defined on the basis of two dimensions: (1) structural levels of definition and (2) the time horizon. The structural levels are indicated on a continuum from weakly to well defined systems. Following

Figure 3: **A Taxonomy of Planning Methods** (on the basis of time horizon and degree of accuracy of description of social and societal systems).

weakly defined system	3.1 Free Form Games: frame games	3.2 Scenario Methods frame games	3.3 Scenario Methods frame games	norms stratum (culture) values
	2.1 Rigid Rule Games: operational Interactive simulation/ games	2.2 Interactive simulation/ games	2.3 Cross Impact games frame games	decision making stratum (structure) communi-cation
well defined system	1.1 Econometric models, computer simulation, input-output models, moving average, time series analysis	1.2 Systems Dynamic models interactive simulation/games	1.3 Cross impact analysis/ games frame games scenario methods	causal stratum (technology) work procedures
time horizon of planning	short-term	middle-term	long-term →	
system definition	well defined		weakly defined →	

Klabbers, 1985:141

the vertical axis from top to bottom, the norms stratum (culture) is characterized as weakly defined; the decision-making stratum (structure) has more definition; while it is assumed that the causal (technology) stratum, as it is based on more and better data, is well defined.

A time horizon indicates the level of accuracy of a plan or forecast. A short-term plan is assumed to be more accurate and reliable than a

long-term plan. At the same time, following the system definition from well defined to weakly defined along the horizontal axis shows that the presently well defined system becomes less well defined in the long-term. (These time periods are relative to the system involved. For instance, in some systems a short-term period will consist of days or months, while a short-term period for others will be considered in years or decades.)

A brief overview of the matrix on Figure 3 reveals nine cells in which a diversity of simulation models are suggested for use according to the levels, definition and time horizon of a system. Cells 1.1, 1.2, 1.3 relate to planning methods for well defined systems in the causal stratum from a short-term to long-term basis. Cell 1.1 relates to short-term planning methods in a well defined system and is characterized by algorithmic methods used in econometrics, computer simulation and input-output models that rely on numerical information. These methods are useful for short-term technical planning. In an educational system this would include short-term planning or projection models on student enrollments. Cell 1.3 relates to long-term planning methods such as "student enrollment assessments" in a narrow sense. If an enrollment assessment were to include, for instance, impacts on vertical or horizontal coordination or communication or school values or attitudes toward student enrollment projections, it would be necessary to include those planning methods characteristic of cells 2.3 and 3.3.

Cells 3.1, 3.2 and 3.3 relate to planning methods for weakly defined systems in the norms stratum. Cell 3.3 relates to long-term planning methods in a weakly defined system and is characterized by conceptual models where norms and values are important.

Cells 1.1, 2.1 and 3.1 cover an area of planning that moves from short-term technical planning methods to short-term normative planning methods integrating all three strata of social systems. For example, in the context of an educational system, a short-term plan for increased enrollments and educational access can be limited to input-output models of numbers of students (1.1), but it also might include the desired state of the composition or mixture of students that would require communication and coordination (2.1) as well as more weakly defined values related to increase the student composition (3.1).

Summary

Gaming simulation has a history of use dating as far back as 3000 B.C. in Chinese history. Currently gaming simulation is gaining in popularity of use. The characteristics of simulation and gaming summarized in Table 1 indicate its usage in academia; Table 2 summarized characteristics of science and public policy and a discussion followed arguing for a combined usage of policy and research. The planning environment and the taxonomy of uses discussed indicate that gaming simulation has the possibility of providing a technique to bring together different disciplines and groups of people in a way that is compatable with the present and future policy making and planning environment.

PART III: THEORY, TYPOLOGY AND DESIGN

Game Theory

Game theory is a mode of study of conflict and cooperation and is oriented towards mathematical methods in the study of decision-making (Shubik, 1983). Gaming does not necessarily require knowledge of game theory, but game theory is useful in the design, construction and analysis of games for their application to planning and policy making.

Most formal game theory is characterized by assumptions of rational behavior and expectations. It is assumed that individuals are capable of accurate and virtually costless computations, that they are completely informed about their environment, that they have perfect perceptions, possess well-defined goals and that the goals do not change over the period of time during which the game is played.

Game Forms: Extensive, Strategic, and Characteristic Function

In game theory there are three main or formal descriptions, or forms, of a game which are important for designers and users of games. These forms help in the understanding of the nature of the reward system or the payoff that is used as the motivation pattern in the game and who is being motivated. The three forms are (1) the extensive form, (2) the strategic or

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* The literature on game theory is extensive and much of it developed from military gaming. This discussion of game theory for gaming simulation is abstracted from "A Game Theory Background for Gaming," in Martin Shubik's **Games for Society, Business and War: Towards a Theory of Gaming** (New York: Elsevier, 1975), pp. 29-202. Though not as helpful for current discussions on gaming simulation purposes, the classic work on game theory is the **Theory of Games and Economic Behavior**, by J. Von Neumann and O. Morgenstern (2nd ed.; Princeton: Princeton University Press, 1947). A comprehensive summary of game theory is R.D. Luce and H. Raiffa, **Games and Decisions: Introduction and Critical Survey** (New York: Wiley, 1957). For other overviews, refer to Owen (1962), Rapoport (1966,1970), Davis (1970), May (1970), Bacharach (1976), Vorobev (1977), Aubin (1979) and Jones (1980).

normal form and (3) the characteristic function form. The selection of the form by which to represent the relevant features of a game is tantamount to the selection of a presolution.

(1) In the extensive form the game is described as a tree where every possible choice is represented by a branch. All choices which are made at a certain point of time, with given information, are represented by branches from the same node.

(2) In the normal form the game is "collapsed." Each decision maker at the start of the game will choose one strategy, where a strategy is defined as a total plan of how to behave in every conceivable situation. In the normal form every decision maker thus makes only one real decision and hence there is no interaction.

One class of games illustrated in the normal form is the two-person, zero-sum game, or the game of pure opposition. A zero-sum game is a game of pure opposition because one player loses precisely the amount that the other player wins. In a game of pure opposition, talk, language, communication and negotiation have no role. In this situation there is nothing to talk about; actions speak louder than words; one person's win is the other's loss; and there is no community of interest. Chess, checkers, two-person poker are examples of games of pure opposition, zero-sum games. However, most social situations cannot be modeled as two-person zero sum games.

> The fact that almost all of human interaction involves a complex mix of parallel and opposed interests is of fundamental importance to the behavioral sciences in general and to game theory and the interpretation of gaming in particular. When interests are not directly opposed, individual, rational or intelligent behavior may no longer be easily related with rational or intelligent social behavior. (Shubik, 1975:62)

As soon as one turns to a theory of "nonrational playing," the normal form will, in most cases, no longer be of interest since there is no intrinsic reason why the parties should commit themselves to such strategies if they are not following game theory's rationality assumptions. The analysis in the extensive form will still be of interest, since it relies only on the institutional assumptions. Hence, there is a connection between gaming and game theory in the extensive form. The normal form, which does not allow any interaction, is only of interest from a simulation viewpoint for the case of very simple noninteractive games.

(3) The characteristic function form is useful in considering situations of cooperative behavior with more than two parties involved. It is understood in this situation that players may easily get together outside of the context of the actual game to arrive at some type of jointly optimal outcome. Thus the solution to a cooperative game is more oriented towards the distribution of proceeds than the actual play of the game. Once all individuals have agreed to cooperate, the strategic aspects of the game are not terribly important, but the distributional aspects are critical.

Types of Games: Rigid Rule and Free-Form

There are two types of games that can be classified according to the formality of their rules. They are called rigid-rule gaming and free-form gaming.

(1) Rigid Rule gaming is one in which all the rules are completely specified and well defined in advance. The outcome of every possible combination of players' decisions is exactly defined. Rigid rule games are characterized as "environment poor" because the number of variables is highly limited and the emphasis is on limited representation of reality.

Emphasis is placed on the abstract structure rather than on institutional or environmental details. Non-computerized rigid-rule games can be understood easily and quickly. These games can also be easily computerized. There may be a disadvantage to rigid-rule human-machine games, where the individual works directly with the computer, for such a case requires an acceptance of the validity of whatever is modeled into the "black box."

> The more that is hidden in bigger and fancier black boxes the less is seen and the more one promotes a division between the users -- receiving the oracular pronouncements from the black box -- and the priests of the model, i.e., those who feed the black box. (Shubik, 1983:18).

(3) The Free-Form game is one that allows some of the institutional assumptions to be supplied by the participant game players. Not everything is completely defined in advance; some rules are invented as the game proceeds. These games are characterized as "environment rich" as attention is paid to institutional detail, context and to the problem of realistic scenario presentation. The understanding, either implicitly or explicitly, is that the game is not completely known and that the playing of the game will in itself serve as a device for generating a better understanding of the rules. The emphasis on the participation and quality of the individuals is higher in free-form gaming. The value of a free-form game may be highly related to the expertise and sophistication of the players and the presenters of the game.

Game Theory Solutions

There are several concepts that characterize the properties of different solutions. The general solution classes are (1) noncooperative, (2) cooperative and (3) mechanistic solutions.

(1) Noncooperative solutions. Noncooperative solutions stress no communication, conflict of interests, or competition and the resolution of problems by the unilateral application of force. Specific solutions in this class are:

The Maximum Solution - when applied to zero-sum games, stresses individual rational behavior in a situation involving pure opposition or conflict. It is the suggested way to play on the assumption that the individual and opponent are each individually rational. The game theory solution in this case provides a great deal of guidance to the gamer especially when studying tactical situations, such as duels. In general, this solution is of use in military problems but is of limited use in non-military problems which are very rarely well characterized by a zero-sum or constant-sum assumption.

The Noncooperative Equilibrium - reflects the individual application of strategic power in a situation with low communication. If all parties follow this type of behavior, frequently the outcome will be far from optimal for all of them. There is some experimental evidence with business games in favor of this solution.

Beat-the-Average - stresses "damage exchange rates" among the players. In some sense it can be regarded as a key solution concept for "illfare economics." An individual is willing to sustain virtually any loss provided that the others lose more or at least as much. This solution concept is of considerable importance to the gamer, as frequently experimental

subjects or others, while playing a game, convert the game from one whose goals are given, into a competition among the teams where the goal of winning becomes synonymous with doing better or beating the other teams, regardless of cost.

(2) Cooperative solutions. Cooperative solutions stress high levels of communication, the exploration of common interests as well as conflict. The presumption is that the individuals will cooperate to achieve an efficiency that is of benefit to all, but will be in conflict over distribution. Specific solutions in this class are:

The Core - stresses the power of groups. The final resolution of the game will lie in the set of outcomes within the core, inasmuch as they are both rational from the viewpoint of society as a whole and rational from the viewpoint of all coalitions. For the gamer, the core is in some sense a measure of the importance of countervailing power and the possibility for group agreement. When the core does not exist, this means that there are groups in society which must necessarily be in conflict.

The Value - stresses the concept of fair division. It is best interpreted as a normative solution suggesting how individuals should divide joint proceeds. It serves as a benchmark for the gamer inasmuch as deviations from the value can be looked at as measures of the social structure or bargaining effectiveness among the players.

The Nucleolus - is a measure which tells the game designer how much the groups must be taxed or subsidized so that the resulting game just has a core, i.e., so that it is just barely possible to have both group and social rationality satisfied simultaneously.

The Bargaining Set - is a collection of bargaining points that can arise in a game. The points are characterized by a stability against the proposals and counter proposals of the members of the coalition. The set stresses bilateral bargaining with allies. It is of interest in games devoted to studying coalition formation. The kernel and the stable set are subsets of the bargaining set. The kernel is used where there is a symmetry in the strength of every pair in terms of the best alternative available to each individual; the stable set stresses the concept of social stability.

Mechanistic solutions. Mechanistic solutions include the price system and voting where each individual honestly votes according to his or her preferences. These solutions stress decentralization of decision making. The "price system" is a mechanistic solution concept that applies to situations involving economic organization. An important aspect of the price system (assuming certain technical conditions hold) is that it permits a decentralization of decision making to allow individuals to operate separately merely by making choices based on prices.

The Relationship Between Game Theory and Gaming

There is a two way relationship between game theory and gaming. It has been stated above that the limitation of formal game theory is that it assumes 100% behavioral rationality. The structuring, building and analysis of games is based in game theory. Sociological, psychological and other variables, including new solution concepts are based in gaming.

Shubik (1975) notes four key words that can be used to describe the contribution of game theory to model building for gaming. They are: explicitness, aggregation, symmetry and sensitivity.

Explicitness - Game theory calls for detailed and clearly expressed explanations.

Aggregation - The choice of appropriate levels of abstraction depends on aggregation. The abstraction depends on the questions to be studied. Varied questions change the description.

Symmetry - In the construction of formal models, and in analysis, there are two types of symmetry that are important. External symmetry includes the characteristics of players or of the external environment that are assumed to be the same to all. Internal symmetry characterizes the actual structure of the game. Explicit assumptions regarding both types of symmetry are important in the design of games. Lack of symmetry introduces biases into games.

Sensitivity - Minor changes can sometimes cause large changes in behavior. Sensitivity analysis is important to all uses of gaming exercise, for which formal theoretic analysis can be useful.

A Typology of Gaming Simulation

The uses of gaming have been extensive. The disciplines most heavily involved in the utilization of games have been: management science and operations research, psychology, education, political science, sociology, military science, and economics.

The uses of gaming have been broadly described under various categories: teaching, training, operations, research, therapy, entertainment, experimentation, futures studies, or structural brain storming (Shubik, 1983; Stahl, 1983). Stahl has presented a typology that includes five categories in which games are used. They are: entertainment games, educational games, experimental games, research games and operational games. These five

types are presented in Figure 2.

Entertainment games are those which are for recreational purposes alone and which are intended to produce results of immediate value which are obtained during the playing of the game. No remaining value is necessarily intended.

Educational games are those which are intended to produce benefits to the player of a long-term and general nature.

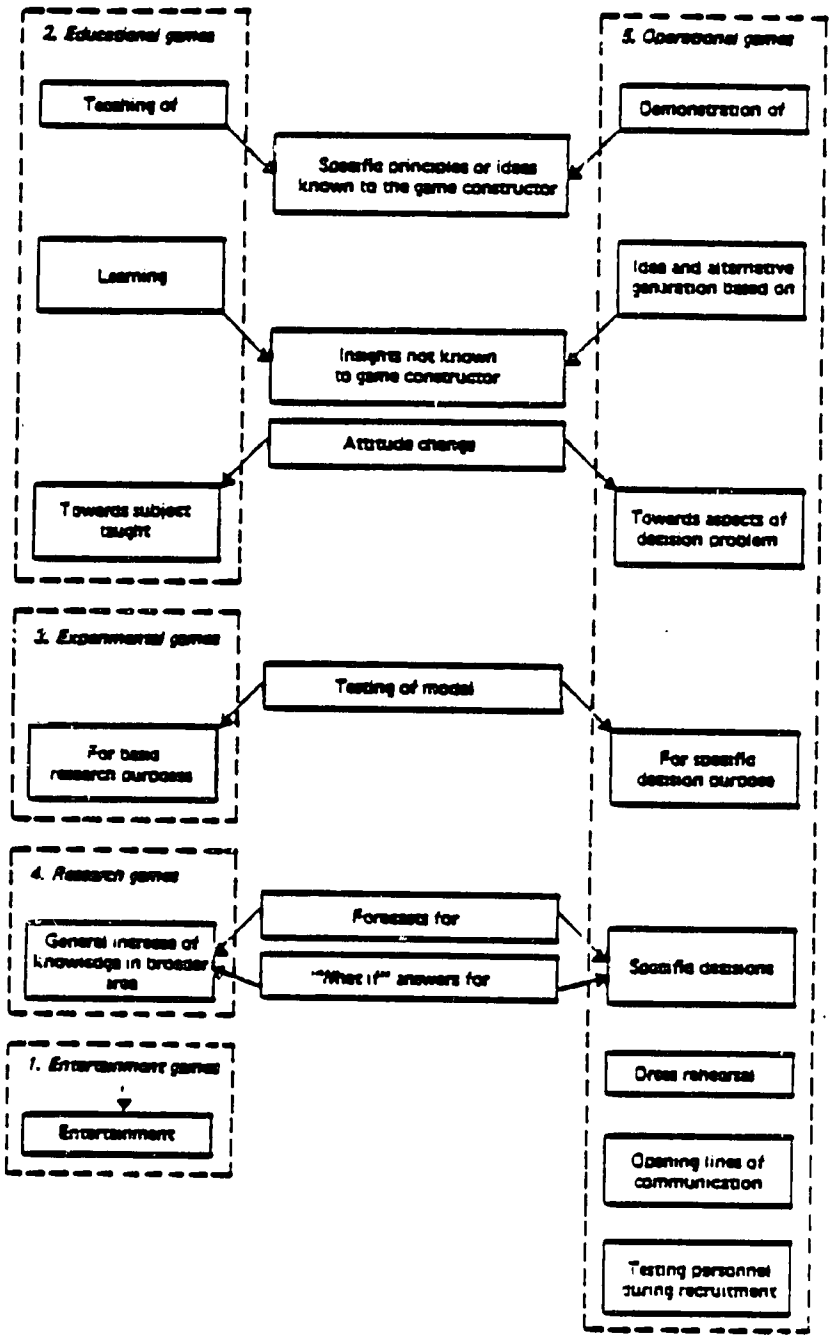
Experimental games are those aimed at testing theories or other general hypotheses, without a specific empirical content, without a specific situational context, and without having any specific type of application in mind. The intended benefits lie in a report to outsiders on the results of the game playing.

Research games are those intended to produce empirical material, such as forecasts, concerning a fairly broad subject area and where the application of this material for decisions is not immediately apparent. The main planned benefits lie in the reporting of the results to an outside audience.

Operational games are those with the purpose of aiding decision making, planning, and policy implementation in specific situations. The main benefits are fairly immediate. No reporting to outsiders is required.

Figure 2 shows that several categories are similar and the borderlines between the five types of games are not distinct. For instance, some educational and research games can be very close to operational games for demonstrating specific issues to management. Stahl suggests that another category is required that includes research and calls it "operational research games" (Stahl, 1983: 35).

Figure 4: A Typology of Games



Source: Stahl, 1983: 33

Table 4: A comparison of four types of games.

Dimension	Type of game			
	Experimental	Research	Operational research	Operational
1. Subject	Six-person core game	Cost allocation	Cost allocation in water management	Cost allocation in one specific water project
2. Purpose	Testing cost-allocation methods	Testing cost-allocation methods	Finding cost-allocation methods suitable for water projects	Speeding up agreement in actual project
3. Players	Undergraduate students	Graduate students in economics	Water planners in different countries	The actual decision makers
4. Data	Artificial figures, round numbers, symmetry	Figures artificial but derived from economic theory	Real figures from some water project	Figures from specific project
5. Setting	No administrative setting	Indication of artificial administrative setting	Real administrative setting outlined	Administrative setting exactly known

Source: Stahl, 1983: 36

> An operational research game, like an operational game, has the ultimate purpose of being an aid for decisions, planning, and policy implementation, but unlike the operational game it is not focused on one single decision situation but rather on several situations involving a specific type of problem. The operational research game is thereby directed more towards the development of methods than the pure operational game. Another difference vis-a-vis the pure operational game is that the planned value of the game lies in communicating the results to future decision makers, while in the (pure) operational game no such communication is necessary. (Stahl, 1983: 35)

Table 4 shows that the same game could be used for various purposes, but that the types of players, the actual data, and the background information would vary.

Elements of Game Design

Over the years, aspects of the design of games have been described by game designers. Until recently, few game designers have been able to clearly articulate the process and many refer to their work as more of an art than a methodology that is definable and reproducible. Indeed, this is reflected in the lamentations of leaders in the field and summed up by Duane Dillman:

> There are no handbooks, few articles or books and few references which contain any useful technique of game construction (Shubik, 1968; 644-646; Instructional Simulation Newsletter, July 1968; Boocock and Schild, 1968; 266)(Dillman, 1970: 3).

Three other leaders in the field, David Crookall, Danny Saunders and Allan Coote issued a similar lament sixteen years later:

> ...the newcomer or student has little material, other than the finished game and instructions on running it, to provide guidance on design paradigms in general, or on a particular design procedure followed for a given simulation, or yet on the underlying model. S/he therefore often falls back on intuitive judgement, informal advice from others, theoretical descriptions

of the design,process, or inspiration." (Crookall, Saunders, and Coote, 1987: 2)

Segments of game design have been described by a few gamers (Inbar and Stoll, 1972; Laufer, 1973; McLean and Raymond, 1976; Thiagarajan and Stolovitch, 1978; Ellington, Addinall and Percival, 1983; Jones, 1986). The most complete treatments of game design methods and process are those of Richard D. Duke (1974) and Cathy Stein Greenblat (1987).

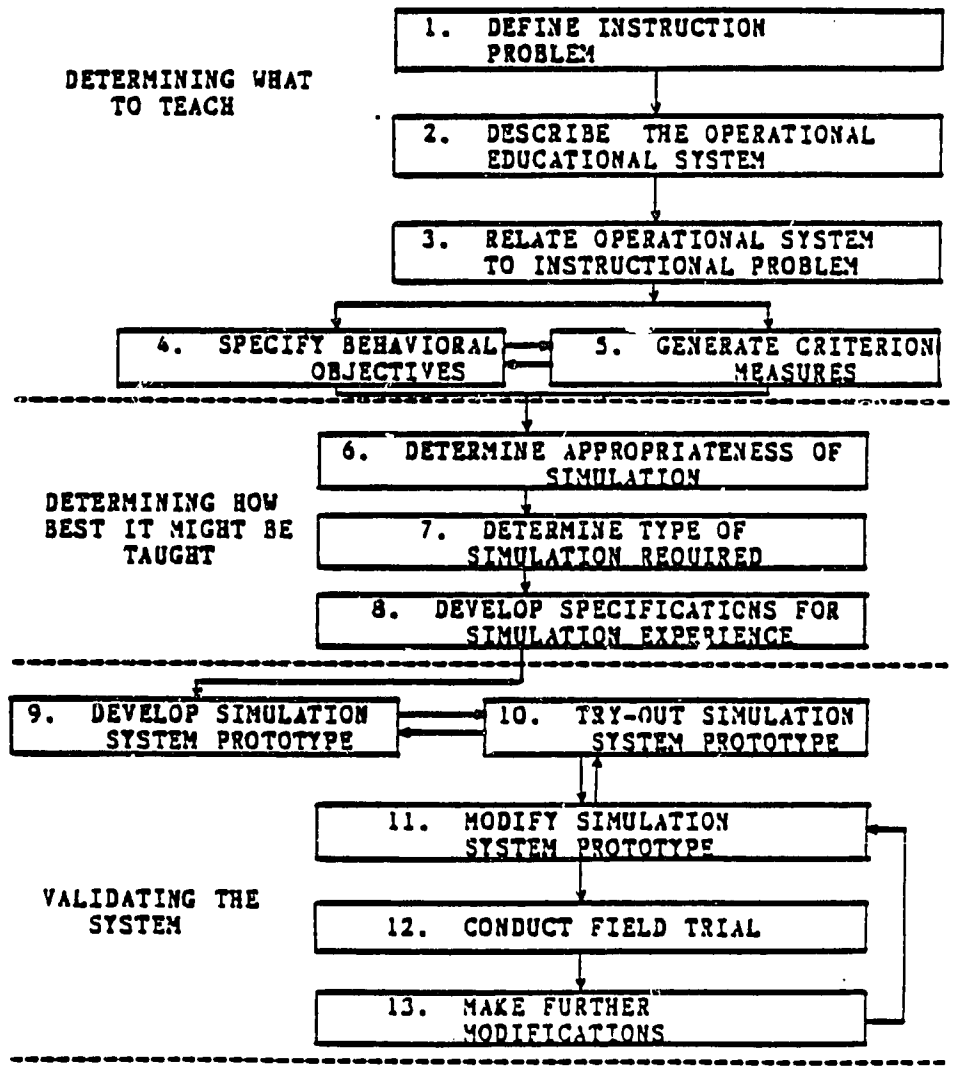
Four designers offering different approaches to game design will be compared here. Paul Twelker (1969) describes a systematic approach to defining the problem, context and objectives of the game. Richard D. Duke (1981) describes a conceptual map approach that gives an overview of the design, construction and intended use of the game. Cathy S. Greenblat provides a dynamic process of game design that integrates approaches exemplified by Twelker and Duke. Jan Klabbers (1980) describes the structure and specifications for designing an interactive gaming simulation.

A Game Design by Twelker

Twelker lists 13 steps in the game design process displayed in Figure 3. Steps 1 - 5 determine what the problem is, the constraints of the educational system and the learning objectives. Steps 6-8 specify how information about the specific problem migh best be taught. The end product is a model of the system being gamed and is considered the blueprint for construction of the game. Step 9, on building a prototype is vague. Twelker says that at this point, a good share of the work of the simulation system design has been accomplished, and the 'fun' of building the system begins. The main task is

to translate instructional blueprints into a prototype and the more complete and thought out the blueprints, the faster and easier the development. Steps 10-13 illustrate a process of gathering information, testing results and looping back through the system a number of times until the designer, the client and the audience are satisfied with the completed model.

Figure 5: Game Design Steps by Twelker

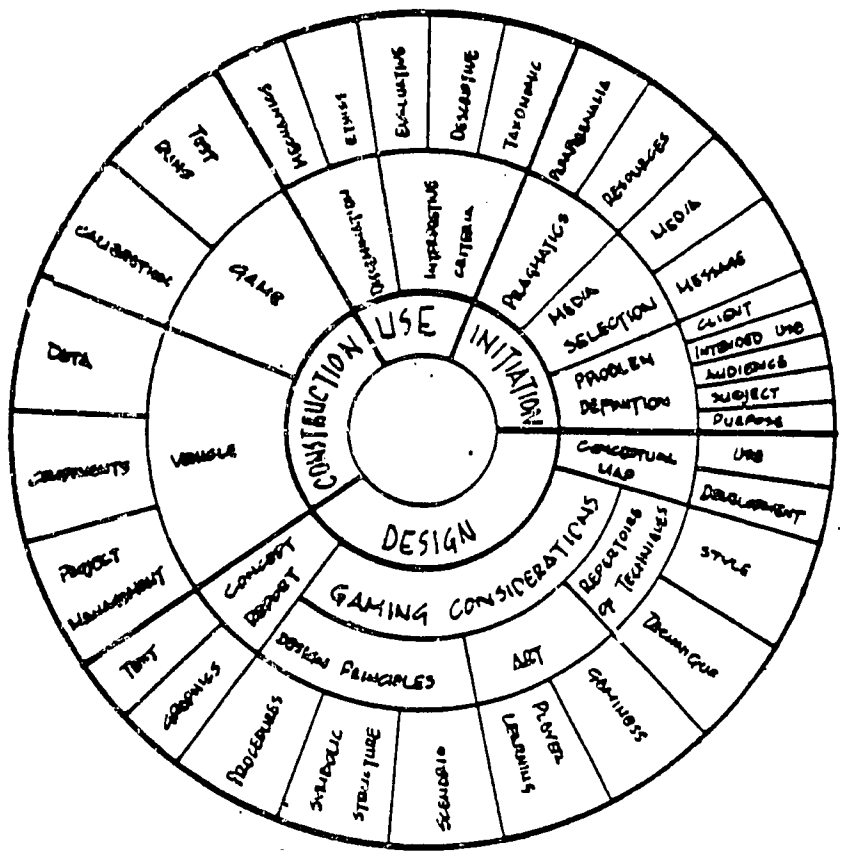


Source: Twelker, 1969: 66.

Game Design by Duke

Duke presents a four stage method of development that he has outlined in eight steps. Figure 4 presents Dukes illustration of the game design process: initiation, design, construction and use.

Figure 6: The Game Design Process by Duke



Source: Duke, 1981: 48.

The eight-step outline includes:

1. Specifications for game design: A specific statement of what one is trying to achieve. At the conclusion, this serves as the basis for evaluation.

2. Representation of the Problem System:
   a. Brainstorming, captured by 'snow cards'
   b. Organizing the snow cards:
      (1) Sequential (e.g., table of contents)
      (2) Conceptual maps (e.g., wheels)
      (3) Three dimensional toys (e.g., Tinker toys)
      (4) Flow chart (3-D constrained for mathematical representations)
      (5) Other

3. Selection of problem components to be gamed (from a given systems representation such as a flow chart, mark those elements to be included in the game, using specifications for game design as judgemental criteria).

4. Having decided what to game (Step 3), plan how to game it with the systems componet/game element matrix. (This matrix shows the specific way(s) in which a given systems component will be captured in the game design, element by element.)

5. Define each game element.
   a) Describe the <u>content</u> of each game element; summarize the notations from all cells for each column the systems component/game elements matrix (scenario, pulse/event, roles, decision sequence, cycle sequence, steps of play, accounting system, model, indicators, symbology, paraphernalia).

   b) Using the ideas from your 'repertoire of games' describe ideas about how each of the game elements will be represented.

6. Game construction

7. Game evaluation (based on the 'specifications for game design')

8. Field use.

Duke's approach seems to be very complete in the 'how to' of game design up to point 5-b, which states, "using ideas from your 'repertoire of games,' describe ideas about how each of the game elements will be represented." If the game designer has had some experience with theory, design and playing of games, his/her repertoire could be extensive. If not

experienced he/she would have no repertoire or even a reference system to a repertoire. At this point it is advisable to turn to Greenblat (1987).

Game Design by Greenblat

Greenblat presents a five-stage design process that includes the elements of Twelker and Duke as listed above while integrating her own experience as well as those of others. The discussion is rich in detail, containing more than 90 figures from case study games to illustrate the design process. An outline of the five-stage process is as follows:

Stage 1: setting objectives and parameters;

Stage 2: model development;

Stage 3: decisions about representation;

Stage 4: construction and modification of the gaming simulation;

Stage 5: preparation for use by others.

The first stage requires the delimiting of the subject matter, purpose, intended operators and participants and context of use for the gaming-simulation. The second stage entails the development of the system and selection of elements for inclusion of the game and requires a verbal and graphic description. Stage three includes decisions of style and form. Style includes consideration of the appropriate level of abstraction, time frame, structure and flow of activities and the amount and type of interaction to take place between participants. Concerning structure, Greenblat draws from Ellington, Addinall and Percival (1982) who suggest that gaming-simulations are one of three basic structures, or composites thereof -- linear, radial and interactive.

A linear structure allows players to progress through a sequence of events to enable complicated cases or procedures to be broken into manageable steps for the development of skills.

A radial structure allows different players or groups of players to carry out activities regarding a particular problem or circumstance using varied resource materials to present a case in a plenary session or simulated meeting. This exercise allows for different arguments or points of view to be examined and is useful in the development of communication skills and beneficial attitudinal traits such as listening to other points of view.

An interactive structure is an important feature of gaming-simulations where there are multiple interactions between individuals or groups. The interactions can take place through information exchange, trading, negotiation or lobbying. In comparison to the tightly-structured linear or radial games, the characteristics of gaming-simulations with an interactive structure are that they are looser, more informal and less predictable. The interactive structure is useful for simulating complex social situations and group dynamics, developing communication skills.

Form includes decisions about how each model element is to be represented, including the scenario, roles, procedures and rules, visual imagery and symbols (such as maps, game board, blocks or beans) and the external factors (such as chance cards, radio broadcasts or letters), or as part of the accounting system (such as statements governing the initial distribution and subsequent redistribution of resources).

Stage four calls for the writing of scenarios and role descriptions and the construction of other selected elements of the gaming simulation; all parts are then assembled into a prototype and the gaming-simulation is

field-tested until it operates successfully. Stage five calls for the preparation of the game for use by others. It is important that the designer of the game is not one of the "necessary materials" for a successful run, therefore an operator's guide is an essential part of the design process. Other considerations include copyright, publication, packaging and distribution.

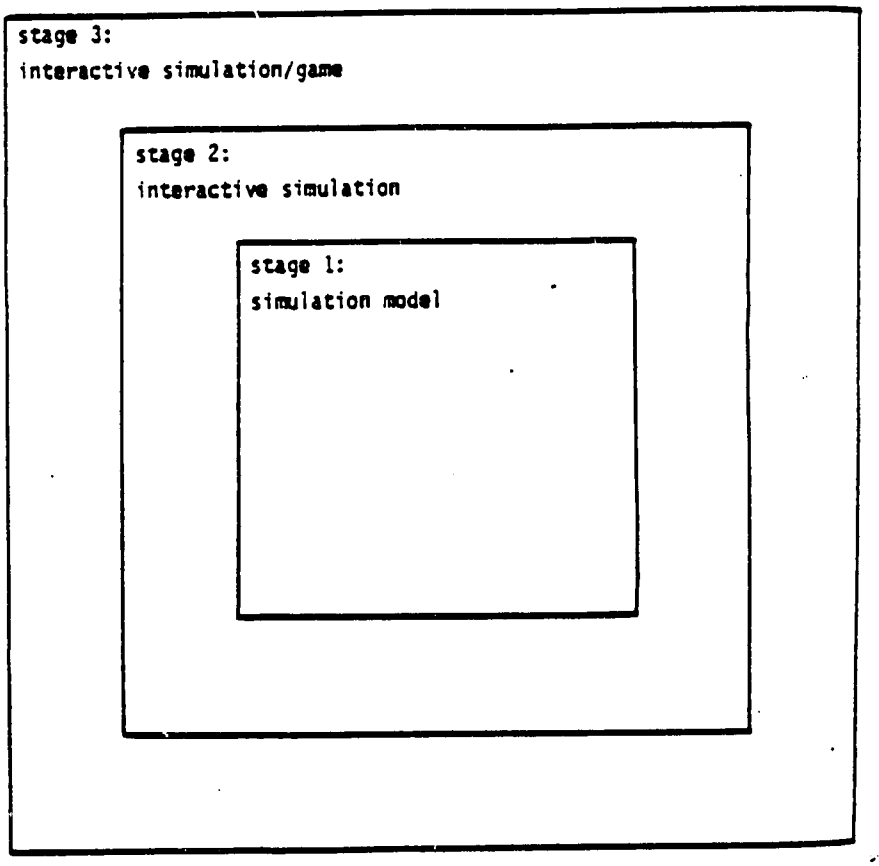
Greenblat also includes some description of the use of microcomputers as aids in the design process and in game operation. Most of the discussion is focused on design tasks that are facilitated by computer capabilities in: (1) word processing; (2) graphics and imagery useful in preparation of game kits for publication; (3) for thought-organizing programs such as THOR, ThinkTank, and Idea Processor; and (4) for the utilization of computer modelling programs. Computers are also utilized in the operation of games to facilitate calculations, to communicate between teams or to give players access to a database. Greenblat's discussion of the use of computers in game design regards computers as helpful tools. For those considering a more integrated approach to the use of computers in the design of games for policy and planning, Klabbers, et al. (1980) offer another approach.

Game Design by Klabbers

The development of an interactive simulation game involves further considerations in the design process because it takes place in three stages:

1. development of the simulation model;
2. embedding of the simulation model in an interactive simulation;
3. embedding of the interactive model in a game.

Figure 7: Structure of Interactive Simulation/Game by Klabbers



Source: Klabbers et al., 1980

Klabbers et al. point out that the goals for each of these stages vary. The goal of the all-computer simulation is to emphasize the quantitative aspects relating to analysis of social systems at the technical mathematical level. The goals of human-computer simulation include qualitative aspects of human behavior such as transfer of information and skill concerning dynamic characteristics of the simulation model in interaction with individual strategies; the study of individual values and norms; learning and

exploration on how to cope with complex phenomena.

Goals of gaming incorporate the prior goals but are also related to interaction between and in groups; to human organizational aspects; and to communication, social learning and policy formation.

There are two phases and 17 steps in this design process. The two phases are distinguished as (1) the conceptualization phase, "which in general consumes about 60% of the total time and effort" and (2) the formalization phase during which the mathematical model is developed and analyzed. The steps are as follows:

Conceptualization:

1. Identify problem
2. Formulate the problem
3. Define the time horizon
4. Choose system boundaries
5. Choose level of aggregation
6. Define the elements of the system
7. Define matrix of cause-effect relationships or draw a flow diagram of causal relationships
8. Make a verbal description of processes indicated by step 7
9. Verify this (qualitative) model

Formalization:

10. Map causal network into mathematical system (i.e., allocate elements of the qualitative model to system variables)
11. Define system equations
12. Choose approprite programming language and program mathematical system
13. Estimate parameters
14. Perform sensitivity analysis
15. Carry out scenario analysis
16. Compare the results of the analysis with available knowledge about the actual system
17. Draw consequences

Klabber's approach to gaming simulation design is important because it directly addresses the issue of the integration of computers in the gaming simulation. There has been little discussion anywhere and no analysis or

evaluation could be found on the types of computers, computer hardware and/or software models for use in the game design process itself. Microcomputer technology has changed the field of gaming simulation dramatically. The following section looks at four ways that computers are being used in gaming simulation.

Human and Computer Involvement in Simulation

Computers first became valued in simulations because of their obvious mathematical capabilities. The fast calculator was used as one of the first computers in simulation. Soon the simulations came to be designed entirely for the computer, and more recently the computer has come to be used as more of a support tool. The spread of microcomputers has encouraged an almost exponential growth in the use of computers in simulation activities. This has been the case with the majority of commercialized computer simulations that appeared during the early 1980s. "The machines were used in a way that made impossible the rich social interactions that are essential to most policy-related games" (Meadows, 1985). "It was often the computer program, not the simulation it supported, that sold the package. The way the program worked (for instance, screen presentation) tended to be the determining factor in the decision to buy, not the learning potential of the whole package qua simulation" (Crookall et al., 1986).

A Computer Simulation Typology

Crookall et al. (1986) offer a working typology for computer simulated gaming. They suggest that there are four dominant issues involved in human-computer simulation gaming. They are addiction, social interaction, restricted access, and models and decisions. In some cases, computer

simulations could prove to be so enjoyable that people could mistake what they represent for other more human aspects of social life. Much will depend on the way they are presented, used, and critically discussed in the debriefing session.

Studies by Greenfield (1984); Kohl (1982); Levin and Kareev (1980) claim that computers provide realistic social interactive encounters for their users. However, Crookall et al. (1986) point out that learning opportunities may be more limited with some types of computer simulations than others. The most obvious restriction involves the relative absence of other people in the typical computer simulation. The exclusion of many important dimensions of social interaction from the exercise oversimplifies essential aspects of group decision making and interpersonal communication.

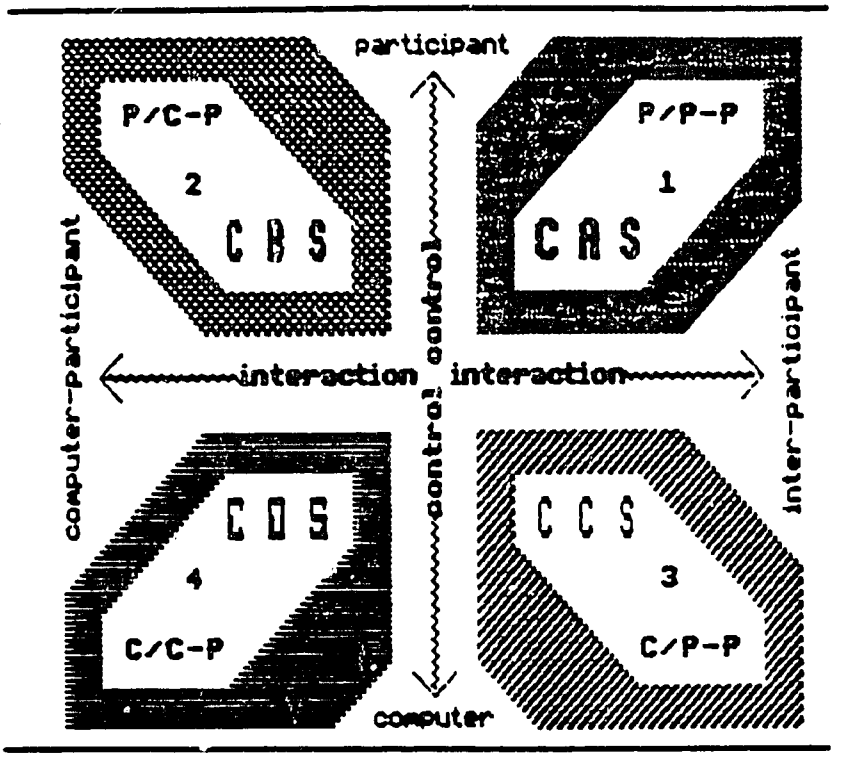
Most people have limited access to computers, especially in organizations and work environments. Two groups can be identified: the computer specialists and the group. Communication between these two involves a set of complex and subtle negotiations about the meaning and interpretation of the information. This is a well-documented phenomenon in social psychology, usually referred to as the "two step flow model" of communication (Katz, 1957; Katz and Lazarsfeld, 1955). It seems important, therefore, that particular care is taken to ensure that the computer simulations do not oversimplify or, worse, ignore group processes, human communication, and social activity that takes place away from the computer.

Gaming simulations that involve a computer model have the potential to allow players to experiment with technical factors (production levels, marketing strategy), and to experience a fundamental aspect of organizational life -- that of bargaining and negotiation in the

decision-making and reality defining process. In a management simulation, for example, they may be faced with the inevitable interdepartmental rivalry so common in organizations. This is particularly relevant in view of the increasing literature on the sociopolitical aspects of power, bargaining, and decision making in organizations. Earlier rational models of organ-izations are now in dispute. Other fields of study have also begun to show the shortcomings of orthodox assumptions and to analyze the essentially human and complex nature of social interaction and negotiation.

Two analytic variables are suggested for their relevance to the assessment of a computer simulation. These are (1) control of simulation and (2) interaction. Figure 8 shows a grid indicating the perspectives of control and interaction in four types of computer simulations.

Figure 8: Gaming Simulation Participant and Computer Perspectives



Type 4 computer dependent simulation (CDS) indicates a situation where users observe the simulation run as members of a theater audience. The computer is being used here as an animated, but teacherless, electronic blackboard. Type 3 computer control simulation (CCS) is a situation where users interact either while the simulation runs or at particular times during the run. Participants may discuss features of the run and attempt predictions. The flexibility of the simulation and its range of outcomes are, however, somewhat restricted by the software. Type 2 computer based simulation (CBS) usually involves a single user who interacts with the computer as the simulation proceeds.

Type 1 computer assisted simulation (CAS) is a situation whereby users are expected to play various human roles in the simulation, so that, for example, decisions are the outcome of interparticipant interaction and negotiation away from the computer. A summary of the main points of this discussion is shown in Table 5.

Summary

Elements of game theory were presented in Part III, and a game typology was offered in which operational gaming was identified as an appropriate type for use in the aiding of decision making, planning and policy. A discussion of four approaches to operational gaming design was offered, leading into the introduction and use of computer technology in the process of game design and implementation. Each of the four approaches is slightly different, reflecting a diversity of design styles. A systematic step by step approach was described by Twelker (1969); Duke presents a design approach in concentric circles (1981); the Greenblat (1987) approach is more

Table 5: Summary of Main Differences Between Computer-Dependent Simulations (CDSs) and Computer-Assisted Simulations (CASs)

Criteria:	CDSs (C-DEPENDENT Ss)	CASs (C-ASSISTED Ss)
control of S events:	mainly by C.	mainly by Ps.
main interactions:	between C & P (Ps face screen & respond to C prompts)	between Ps (Ps face & respond to each other)
P roles:	puzzle solvers & keyboard operators.	social actors in roles of all kinds.
role of computer:	central: to run S and for precision.	peripheral: as springboard to social activity; to enhance S procedures.
type of S:	mathematical puzzle.	social situation.
aim of S:	"winning" against C.	Non-C objectives.
focus of S:	C.	Ps & social interaction.
decision model:	rational (manipulation of mathematical variables).	socio-political (negotiation of realities & meanings).
social situation:	simple.	complex.
human elements:	few.	many.
skills exercised:	technical: logical operations: manipulative.	social: communicational: higher-order, complex.

NOTE: Only two types of CSs have been included. P = participant; S = simulation; C = computer.

Crookall et al. (1986)

integrative, involving thoughts, ideas and experience of many game designers, and Klabbers (1980) integrates the computer in the design process by suggesting an "embedding" of the computer model in the interactive gaming simulation. A computer simulation typology was suggested by Crookall(1986) to guide the designer/analyst in assessing approaches to computer gaming simulation.

PART IV: THE USE OF GAMING SIMULATION IN EDUCATIONAL PLANNING AND POLICY MAKING IN THE INTERNATIONAL CONTEXT

Introduction

During the past decade, teams located at the University of Michigan, at Dartmouth College, University of Utrecht, Moscow State University and other sites around the world have used simulation as a pre-decision tool to acquaint people with the dynamics of specific complex problems, and to help them communicate with each other effectively (see Appendix II for a partial listing of games and sponsors). Several gaming simulations are designed for international application. Though there are no comprehensive surveys, the reports in gaming simulation periodicals give some indication of the extent, transferrability and usefulness of the technique between and among differing national and political boundaries as well as across cultures.

Teams in Western and Eastern Europe as well as in the Far East have used gaming simulation as an aid to policy formulation and planning in a wide variety of settings (Assa, 1983; Marshev, 1983; Osawa, 1983). For example, in the Yugoslavia, operational gaming has been used to plan cattle breeding (Somogyi and Kisimre, 1983); in Sweden cost-allocation methods have been applied to water supply policy (Stahl, 1983); and in the USSR games have been used in the management of large construction projects (Rybalskij, 1983); in Japan gaming simulations have been used in the evaluation of alternative programs for nuclear power plant construction (Kumata and Morita (1975), the determination of alternative programs for highway construction in urban areas (Kumata, Nemoto and Matsuda, 1976) and in business management (Osawa, 1962; Osawa and Miyashita, 1961; Suieshi, 1977).

The array of subjects in this brief listing reflects the paucity of information on gaming simulation used for specific purposes of education planning and policy making. As stated earlier in the paper, however, the trend toward the use in other sectors would indicate that gaming simulation will be more commonly used in educational planning and policy making.

A Comparative Assessment of Three Operational Games

Introduction

In this section, three operational games are assessed with respect to their use in education policy making and planning within the international context. These gaming simulations have been developed within the last five years and represent the state-of-the-art in the three categories of gaming, simulation and gaming simulation. The features of each game will be discussed followed by a comparative assessment based on the information on theory, design and planning taxonomies presented earlier in this paper. The games will also be evaluated on Keys's (1980) three-phase model of learning (Experience, Content, and Feedback).

Keys (1980) three-phase model of learning

Phase 1: Experience - This phase of learning is provided by game play, decision inputs, and team interaction;

Phase 2: Content - Dissemination of ideas, principles or concepts regarding practices and principles

Phase 3: Feedback - Data printouts, comparative team standings, participant and team critiques by game administrator

CAPJEFOS: THE VILLAGE DEVELOPMENT GAME, THE POPULATION AND DEVELOPMENT GAME, and PERFORM, are introduced in this section with references to more detailed reviews of the gaming simulation models and software that are included in Appendix I.

The three games identified in this literature review have been designed and tested during the past five years and characterize the broad range of gaming simulation. Following the definitions of gaming simulation presented earlier in this study, CAPJEFOS (See Appendix 1.1) is an example of a gaming simulation that falls in the realm of gaming rather than simulation; POPULATION & DEVELOPMENT (Appendix 1.2) falls in the realm of simulation and PERFORM (Appendix 1.3) integrates both gaming and simulation. CAPJEFOS and POPULATION AND DEVELOPMENT were designed with educational components as part of a larger system that included other sectors of the economy, while PERFORM was developed as a planning and forecasting tool for use in a particular educational system. A comparative summary of these games is presented in Table 6 on the following page.

Though each of these games was designed for different purposes, and fall in distinctly different areas of the spectrum, they share several common characteristics. As the table indicates, they share several of the same design characteristics. The game form is extensive, rigid rule type and game solution is cooperative. According to Stahl (1983) the game typology classification is operational; PERFORM and CAPJEFOS might also be used in operational research; POPULATION AND DEVELOPMENT is also classified as educational as it teaches specific functions.

The POPULATION AND DEVELOPMENT GAME and PERFORM were developed for use with computer technology. The POPULATION AND DEVELOPMENT GAME was developed to train planners and policy makers in

Table 6: A Comparative Summary of Three Gaming Simulations

Dimensions of Contrast	CAPJEFOS	POPULATION & DEVELOPMENT	PERFORM
Model Dimension:	Gaming	Simulation	Gaming-Simulation
Design Characteristics:			
Analytic Form	Heuristic	Algorithmic	Heuristic/Algorithmic
Game Form	Extensive	Extensive	Extensive
Type	Rigid Rule	Rigid Rule	Rigid Rule
Game Solution	Cooperative	Cooperative or Competitive	Cooperative
Structure	Interactive	Linear	Interactive
General Complexity[a]	High	Low	High
Technological Characteristics	Soft	Hard	Hard & Soft
Computer Requirements	None	IBM PC/256K RAM/2MB	Micro-Computer w/10 MB
Computer Purpose	—	Computer training	Access to data & calculation
Software Requirements	—	HOST	FORMACY
Role of the Computer	—	Central	Peripheral; as spring-board to social activity
Interactive Characteristics			
Human Elements	Many	Few	Many
Participant Interaction	High	Low	High
Player-Computer Interaction	None	Computer- Controled	Computer-Assisted
Player-Coordinator Interact'n	Coordinator-Assisted	Coordinator-Controled	Coordinator-Assisted
Participant Roles	Social actors	Puzzle solvers	Social actors/PuzzleSolvers
Decision model[b]	Socio-political	Rational (manipulation of mathematical variables)	Socio-political and Rational
Social Situation	Complex/Dynamic	Simple	Dynamic
Skills exercised	Social; communicational	Technical, logical operations; manipulative	Social; communicational; logical; manipulative
Game Typology[c]	Operational, Educational, Research	Operational Educational	Operational Research
Academic Realm[e]	Social Science	Econometric/Mathematical	Social/Mathematical
Data Representation[e]	Qualitative with some quantitative	Quantitative	Qualitative and quantitative
Policy and Planning			
Realm	Policy	Planning	Policy/Planning
Taxonomical Strata[d]	Decision/Norms(2.2/3.2)	Causal (1.1)	Decision Making (2.2)
Organization Association[d]	Structure Vertical & Horizontal Communication	Technology Work Procedures	Structure Vertical & Horizontal Communication
System Definition[d]	Medium/Weak	Well Defined	Medium Defined
System Behavior[e]	Subject to change	Set	Subject to Change
Time Horizon[d]	Middle Term	Short Term	Middle Term
Concern for Reality[e]	Meaning of village life and development	Control of technology and planning process	Meaning and some control for university improvement
Concern for Reliability[e]	Village life is subjective and unpredictable	Objectivity and predictability	Limited predictability allowing for subjectivity
Concern for Validity[e]	Based on context of African village life	Based on universal definitions for units of analysis; little social-cultural	Units of analysis based on universal definitions within university context

a. Interdependence between decision variables, uncertainty in the decision situation & constraints on decision time.
b Table 5: "Differences Between Computer-Dependent Simulations..."
c. Figure 4: "Typlogy of Games."
d. Figure 3: "Taxonomy of Planning Methods."
e. Table 1: "Summary of the General Characteristics of Gaming Simulation."

developing countries in the use of computer technology and forecasting, therefore its focus is functionally specific: to develop technical skills. The computer plays the central role in this simulation; the decision model is based on a rational approach requiring the manipulation of mathematical variables; participant-computer interaction is high. The role of each player is as a puzzle solver whose job is to refine work procedures involved in educational planning; the game could also be used in the aggregation/problem solving stage of policy-making.

The system is well defined and linear; behavior is set in the short term and the concern for reality is with the control of technology and the planning process. Data is quantitative and is based primarily on econometric models using universal definitions for units of analysis. The algorithmic simulation capabilities of this model allow for its usefulness in the planning context. Its use in policy making is limited because it does not include heuristic qualities of a social or political nature and is limited in its ability to predict accurately for long-term periods.

CAPJEFOS, by comparison, has no computer requirements, the interactive characteristics are high. Participant roles are as social actors and the decision model is of a socio-political nature. The CAPJEFOS model was designed to simulate the development process negotiated between the villagers and development experts in the sectors of education, health and agriculture.

The skills exercised are socially complex; the communication structure is both vertical and horizontal and highly interactive. The system allows for weaker definition than the POPULATION AND DEVELOPMENT GAME and is subject to change. The concern for reality is with meaning in the context of an African village, which allows for subjectivity and unpredictablity within the system. Data representation is highly qualitative and the concern for

validity in the model is based on the context of village life. The heuristic gaming qualities of this model determine its usefulness in the policy making context at the allocation or oversight stage in which the main impact of social science is related to evidence asessment and persuasion or evaluation studies. Its use in planning is more limited, however it could be used for exploration in the decision making in the understanding of the structure of village systems or possibly in the norms strata to understand the conflict in values and attitudes between village life and expert development schemes.

PERFORM provides an example of a gaming simulation with highly balanced model characteristics. The model was designed to simulate the decision-making environment in a university in a time funding declines. The computer acts as a forecasting tool that responds to decision inputs made by participants during rounds of negotiations between faculty and administration for short-runs of 1-3 years and long-runs of 10-15 years. The computer gives feedback in the form of forecasting tables on which the next round of negotiations is based.

The model was designed as a frame instrument in which different data can be inserted according to circumstance. In this gaming simulation the computer plays a peripheral role and is used as a springboard to social activity. Participant roles are as social actors and the decision model is a combination of socio-political and rational. The social situation is complex; skills exercised in the gaming simulation are of a communicational nature and also include logical operations and manipulation. The system behavior is weakly defined and also subject to change. The concern for reality is for some control of planning within socio-political environment. In this way, the simulation allows for limited control of the planning process and an understanding that change and unpredictability are inherent to the system.

Concern for validity is based on universal definitions within a given context. The combination of algorithmic and heuristic gaming qualities of this model determine its usefulness in both the planning and policy-making context.

The model is useful in planning because the model contains data of a quantitative nature that is specific to the context. In Klabber's planning taxonomy it falls within the decision making stratum for middle term time horizon and medium system definition. Policy makers will also find it useful because it incorporates heuristic qualities allowing for socio-political validity and would be useful at the allocation or aggregation stages of the policy process.

A Comparative Assessment of Learning with Gaming Simulations

The reason for selecting gaming simulations for use in policy-making and planning is to facilitate the learning process. This section will focus on the games described above in the context of a three-phase learning model suggested by Keys (1980): (1) experience; (2) content; and (3) feedback. Experience is "provided by game play, decision, input, and team interaction" (Keys, 1980:283). Content "includes dissemination of new ideas, principles, or concepts" through manuals or support materials given in the game (Keys, 1980: 283). Feedback is given in the form of output such as tables and charts, points given for team standings, discussion and critiques given during the debriefing by the gaming simulation coordinator or participants themselves. Keys (1980) suggests that learning will be facilitated if the phases are balanced.

Experience Assessment

Based on the amount of participation between participants, CAPJEFOS and PERFORM emphasize the greatest amount of interaction between teams and groups of players. The POPULATION AND POLICY GAME can involve team interaction but it is not specified except by the coordinator of the game and there are no incentives built into the model itself. Rather, the model emphasizes interaction between the participant and the computer.

Content Assessment

The materials provided with all three games are extensive. Content was assessed by the number of total pages in gaming manuals less the total number of pages containing blank forms. The POPULATION AND DEVELOPMENT GAME measured highest in this area. Each game provided statements about the pupose and theoretical concepts and techniques related directly to the game.

Feedback Assessment

Each game provided quantitative feedback. PERFORM and the POPULATION AND DEVELOPMENT GAME provide feedback in the form of computer-generated forecasts. THE POPULATION GAME focuses on data analysis; PERFORM balances data analysis and negotiations, with an emphasis on the latter. CAPJEFOS presents quantitative feedback at the end of each round in terms of team standings, otherwise the focus is on socio-political interactions. Qualitative feedback is provided in both CAPJEFOS and PERFORM but is lacking in the POPULATION AND DEVELOPMENT GAME.

Table 7: Summary of a Comparative Assessment of Learning Through Operational Gaming Simulation

Game and Learning Phase	CAPJEFOS	POPULATION & DEVELOPMENT	PERFORM
Experience			
Group Interaction	High	Low	High
Complexity	High	Low	High
Emphasis on Behavior	High	Low	High
Emphasis on Analysis	Low	High	Medium
Content			
Support Manual	Textual Graphical	Technical	Textual Technical
Gaming Materials	Highly Visual	Highly Technical	Technical
Feedback			
Quantitative	Some	High - Computer Statements	High - Computer Statements
Qualitative	High	Low	High

This brief assessment indicates that PERFORM, CAPJEFOS and the POPULATION AND DEVELOPMENT GAME, provide feedback with PERFORM at the highest balance and POPULATION AND DEVELOPMENT rating lowest balance. In terms of their use in policy making and planning, this assessment indicates that CAPJEFOS may have a greater ability to convey information more effectively in a cross-cultural environment because of its high rating in visual and graphic materials.

The POPULATION AND DEVELOPMENT GAME will be most effectively used in an environment where the participants have a high degree of knowledge in technical components of the simulation, since the materials and feedback are highly technical.

The assessment results indicate that PERFORM will be most effectively used in an environment where the participants have some technical

knowledge but, since the quantitative feedback is balanced with a high amount of qualitative feedback, technical knowledge is not required.

The assessment results also indicate that PERFORM and CAPJEFOS are more likely to be livelier, more dynamic games. We could also make this assessment without Table 7, by looking at the combination of the interactive characteristics along with the general complexity design characteristic in Table 6. Used together, Tables 6 and 7 present a comprehensive overview on which to base an assessment of the potential use of these three games in different policy and planning environments.

Assessment of the Trend Toward the Use of Computer Technology

CAPJEFOS, the POPULATION AND DEVELOPMENT GAME and PERFORM present examples of state-of-the-art gaming simulations for use in educational policy making and planning. CAPJEFOS offers a highly heuristic, dynamic approach to gaming simulation; the POPULATION AND DEVELOPMENT GAME is based on a more traditional, linear approach; and PERFORM represents a combination of the traditional approach algorithmic modeling which is embedded within a highly dynamic, heuristic gaming simulation.

The design and development of PERFORM from its initial stage on a mainframe computer, to the second stage for use on mini-computer to the present stage of adaptation for use on Macintosh SE microcomputer technology also reflects the current trend in gaming simulation toward the use of microcomputers. Microcomputers present the image that the instruction being provided is the state-of-the-art, and this will enhance the appeal for games that is often lacking because people have an impression that they are playful, lacking in seriousness, or frivolous.

Mini and microcomputers also provide participant advantages since they are far more accessible for use than the mainframes. Input/output devices are also more simplified. Decisions are easier to enter and output of graphic presentations yield information more easily understood than numerical tables.

The major problems with the use of microcomputers concerns incompatibility. Programs written for one program will not run on another. The trend, however, is toward greater compatibility; IBM and Macintosh are developing compatible software systems.

Lack of electrical current is also a problem in less developed countries. Some games are developed for use on battery-powered portable computers to avoid this problem, but some manpower planning gaming simulations require memories in excess of the capabilities of present battery-powered portable microcomputers.

Another area of concern in the assessment of these three games concerns the time and monetary costs involved in developing a gaming simulation. As indicated on the game evaluations (see appendix), each of these games were costly in terms of time and money invested. PERFORM was most costly in terms of both time and money ($400,000 over a 2 1/2-year period, including the development of a manpower planning model which was developed simultaneously); the least costly was the POPULATION AND DEVELOPMENT GAME ($20,000 over several months). PERFORM was assessed as the most balanced game and POPULATION AND DEVELOPMENT GAME the least balanced; this might imply that the more balanced gaming simulation takes longer time and money to develop. For some institutions and groups the investment is too costly, which may help to explain why there are not more gaming simulations. Initial development costs of CAPJEFOS ($40,000)

were twice as much as the POPULATION AND DEVELOPMENT GAME, but the cost in time was equivalent to PERFORM (2 1/2 years) As technological developments continue and more people gain greater facility in the use of new modeling software and knowledge about gaming simulation design, costs should decrease. (A study might be made to compare the relative costs of the first published bound books, for example. Johann Gutenberg would marvel at the desk top publishing systems available today!)

In summary, the introduction of the microcomputer, along with modeling software with heuristic capabilities, increases the possibilities of a broadened use of gaming simulation in general and within policy making and planning specifically.

SECTION V: CONCLUSION

The literature on gaming simulation is extensive. It provides a strong theoretical base for the design and assessment of gaming simulations and currently a practical design base is being developed that also incorporates mini and microcomputers.

The trend toward the use of gaming simulation in policy making and planning is broadening out from urban studies, businesses and corporations where it has been most widely used, to other areas. Three gaming simulations have been assessed in this study that indicate the potential for use in educational policy making and planning within the international context. Assessments of these gaming simulations were based on theories and practical applications reported in the literature. The recent introduction of minicomputers, and microcomputers has spurred greater interest in gaming simulation. Microcomputers offer increased possibilities to combine the heuristic qualities of gaming with the algorithmic approach of simulation. These characteristics have been summarized in Table 1. The implication of a technique such as gaming simulation that incorporates such a combined approach to policy making and planning is that it will help close the gaps that have existed in various approaches to development. An example of the gap between science and public policy was given in Part II (Table 2). Other gaps have existed in planning between those who would follow a rigid, linear path and those who argue for heuristics. A gap has also been perceived between strictly defined qualitative and quantitative scientific approaches to inquiry. However, the interest here is also to focus on methods that help us to understand the <u>connections</u> and <u>relationships</u> between these various dichotomies of thought in order to understand the total system.

Interactive methods are necessary during the turbulent environment existing today (Table 3). Methods used in policy making and planning have begun to include models that represent the complex character of various problems with which decision makers are confronted, while allowing for multi-actor participation within pluralistic social and political environments.

Currently educational reforms are being planned or implemented in many nations around the world. The characteristics of gaming simulation should be increasingly more attractive for use by policy makers, planners and managers of complex organizations due to their potential ability to:

1. Convey gestalt or holistic image
2. Permit the specification of detail at any appropriate level, in the context of the holistic image.
3. Permit the pulsing of specific, tangible inquiries or alternatives to permit correlation with the holistic image and any significant detail.
4. Display, make explicit, or permit the recording of explicit linkages between major segments of the holistic imagery; the creation of an awareness of feedback.
5. Non elitist, universal possibility for use;
6. A future orientation (implying any time frame past or future other than the present).
7. Explore diversity of thought. They are basically transient in format and therefore are able to permit the restructuring or more careful articulation of the problem as viewed by those participating. (Duke, 1981:38)

Appendices

APPENDIX 1

General Guidelines for the Evaluation of Simulation Games for Use in Educational Policy Making and Planning

NAME: Name of the game simulation

DESIGNER(S): Name or names of game designers

CITY, STATE, COUNTRY: Origin of the simulation game

SPONSORING INST: Indicate the institution(s)/units(s) that contributed to financing the gaming simulation, or the institution to which the designer belongs and where the design was constructed.

AVAILABILITY: How easy or difficult to obtain? Give specific source.

PRICE/COPY/STATUS: Package cost, if available.

CREATE/DEVELOP/DESIGN: State the year(s) the game was created or developed. Some games begin with a couple meetings, are worked on intermittently during a period of time between initial date and the time readied for general use. In this case give time span (years: 1982-4) and actual amount of time of concentrated development (7 months), if known.

DEVELOPMENT COSTS: Costs or approximate costs of game design and construction. If information is available, include salary, travel and supplies.

TRIAL EVAL DATE: Number of times, when and where the program was field tested in an educational setting.

REVIEWS/PUB&DATE: List books, journals, newspapers, etc. in which the package was reviewed.

SUBJECT MATTER: State the subject of the game.

PURPOSE: State the purpose or multiple purposes of the gaming simulation - what problem(s) does it address?

CONTEXT OF USE: Describe the context in which the game simulation was designed to be used: professional meetings, conferences, training sessions; as an "opener" or "finale" in a 2-3 day workshop or course.

DATA SOURCE(S): Indicate whether game is based on empirical research and data sources: personal experiences, field work, official documents, census, samples, instruments, statistical data, literature reviews.

TIME: Length of time required to run the gaming-simulation

INTENDED PLAYERS: Describe characteristic types of groups intended for the game, i.e., students, professionals, lay people.

NO. OF PLAYERS: Number of players the game was designed to accommodate

NO. OF OP(S): Number of operators needed to run the game and their qualifications (previous experience with the game, knowledge of particular technology, etc.).

QUAL. OF OP(S): State intended operators and the qualifications necessary to run the game smoothly (previous experience with the game, knowledge of particular technology, etc.)

TECH. & PHYS. REQ: List the technical and physical resources required for the game in terms of computing hardware, facilities space and physical requirements.

*Computing requirements may require calculators or computers -- computer hardware requirements (IBM, 513, harddisk, etc.)

*Facilities space (number of rooms)

*physical requirements (desks, tables, photocopying)

PORTABILITY: State high, medium or low portability in terms of size, weight and technology needed.

VERSION(S)/DATES: State the version and date of the gaming simulation being reviewed. If review is compiled from two or more versions, identify differences and critical elements

MODEL CHARACTERISTICS: List principal sectors, time horizon and degree of complexity or sophistication of the model.

Dimensions: State the area the model lies more within the definition of Gaming, Simulation or Gaming-Simulation.

General Complexity: State High, Medium or Low. Complexity in gaming is a function of interdependence between the decision variables, uncertainty in the decision situation and constraints on decision time.

Analytic Form:

Primarily Heuristic

1. Value/Issue Clarification
2. Rational and Logical Exploration
3. Expert Systems

Primarily Algorithmic

1. Simulates Description/Classification/Analysis (e.g. variables/relationships)
2. Simulates Forecast/State Space Regression
3. Optimizes
4. Control

Game Form:

1. Extensive - Every possible choice is represented in the model such as in a decision tree where all choices made at a certain point of time, with given information are represented by branches from the same node.

2. Normal - Decision made at the beginning of game, each decision maker makes only one real decision i.e. zero-sum game of pure opposition, non-interactive as in chess and checkers.

3. Characteristic Function - Decisions are made by more than two parties and can be made outside the context of the actual game to reach jointly optimal outcome.

Type: 1. Rigid Rule - All rules specified and well defined in advance; outcome of every possible combination of players' decisions is exactly defined.

2. Free-Form - Allows institutional assumptions to be supplied by participants; rules are invented as game proceeds.

Game Solution:

1. Noncooperative - stress no communication, conflict of interests or competition and the resolution of problem by the unilateral application of force.

a. Maximum solution - stresses individual rational behavior;

b. Noncooperative Equilibrium - Individual application of strategic power in a situation with low communication.

c. Beat-the-average - stresses competition among the teams where the goal of winning becomes synonymous with doing better or beating the other teams regardless of cost.

2. Cooperative - stress high levels of communication, exploration of common interests and conflict. Presumption is that the individuals will cooperate to achieve an efficiency that is a benefit to all.

a. Final resolution of the game lies in the set of outcomes within the core, stressing the power of groups;

b. Stresses the concept of fair division, normative solutions suggesting how individuals should divide joint proceeds.

c. The Nucleolus - measures how much groups must be taxed or subsidized, i.e., so that it is possible to have both group and social rationality satisfied simultaneously.

d. Bargaining set - collection of bargaining points that can rise in a game; characterized by a stability against the proposals and counter proposals of the members of the coalition.

e. Mechanistic solutions - Decentralization of decision making where the individual votes according to preferences.

OVERALL EVALUATION: Very general comment(s) synthesizing your and other reviewers observations regarding ease of use, performance and timing.

Strengths:
Weaknesses: Comment as Appropriate
*General ease of use
*Ease of learning
*Degree of participant interaction
*Quality of Documentation
*Degree of operator-dependence

GENERAL COMMENT: Regarding the use of the game in educational planning and/or the potential for use in educational planning. Comment on why this package was reviewed if the reason is not obvious.

REVIEWED BY/DATE:

REVIEWER'S SOURCES: State sources on which review is made: game run-through, source documents and/or interviews with designers or game players. If reviewer has played the game, include place, date and context of game run-through, including number of rounds played and length of time.

APPENDIX 1.1

NAME:	**CAPJEFOS: The Village Development Game**
DESIGNERS:	Cathy Greenblat, Philip Langley, Jacob Ngwa, Saul Luyumba, Ernest Mangesho, Foday MacBailey
CITY, STATE, COUNTRY:	Buea, Cameroon; New Brunswick, New Jersey, USA
SPONSORING INST:	United National Educational, Scientific and Cultural Organization (UNESCO) and the Pan African Institute for Development (PAID) in Buea, Cameroon
AVAILABILITY:	Contact Cathy S. Greenblat, Professor of Sociology, Rutgers University, New Brunswick, New Jersey 08903.
PRICE/COPY STATUS:	$200
CREATE/DEVELOP/DATE:	December, 1982 - January, 1985. Initial one-week design workshop held in Buea in 1982, with 25 participants from 7 African countries professionally engaged in formal or informal training activities or in educational planning. Design completed and field tested in January, 1985.
DEVELOPMENT COSTS:	$50,000 initial grant supplied by UNESCO; additional $20,000 supplied by WHO for fine tuning and graphics.
TRIAL EVAL DATE:	Field tested at three sites in Cameroon: (1) PAID-West Africa, Buea; (2) the Community Development Specialized Training School in Kumba; (3) the Local Government Training Centre (CETAM) in Buea.
REVIEWS/PUB & DATE:	**Simulation & Games** Vol. 18, No. 2, 1987 (pp 282-285).
SUBJECT MATTER:	Factors that hinder and/or promote rural development at the scale of the village.
SECTORS:	Education, Agriculture, Health

PURPOSE:	*Understand factors of development and their interaction *More empathy for villagers and knowledge of their rationale *exploration of what development agent's role could/should be
CONTEXT OF USE:	Teaching or in-service training sessions or educational courses at graduate or undergraduate level. It can also be used to train staff in interdisciplinary work and leadership.
DATA SOURCE(S):	Field work and case studies of 2 villages, case studies of effects of migration provided by the Pan African Institute for Development; interviews conducted by design team on site visits to five villages (Bolifamba, Boanda, Ekombe Three Corners, Bole and Nake, some 1-1/2 hours from Buea). Initial stage of design based on Nake village. In-depth informal interviews conducted with chiefs, school teacher, town crier, palm wine tappers, several men and some women farmers.
TIME:	Minimum - 5 hours (simple version); Optimum - 5 to 8 hours (basic version); Maximum - 8 to 12 hours (full version).
INTENDED PLAYERS:	Middle level development staff and agents in service or training with first priority for village level workers, second priority for division/sub-division/ micro-region workers, third priority for provincial and national level agents. Survey reserch workers, extension staff with technical knowledge but little or no knowledge of social and economic processes, general academic teaching program on development issues.
NO. OF PLAYERS:	Minimum - 20(simple version); Optimum - 22 to 30 (basic version); Maximum - 24 to 35 (full version).
NO. OF OP(S):	Two operators are required for the game, a third person to act as an assistant is helpful.
QUAL. OF OP(S):	This game was intended to be run by training institute staff and students. Two operators should be familiar with it from a thorough reading of the game manual. At lease one operator must be totally familiar with all the details of the game. A third person needs only to be familiar with the

basic character of the game, not with all the details. It is helpful, but not necessary, for one operator to have played the game previously. Simple mathematical computations are necessary score keeping.

TECH.& PHYS. REQ: Simple hand calculations used with scoring sheets eliminate the need for computers or calculators; scenario descriptions, tickets, cards included in game package. Minimally, one large room is required for the basic version; optimally, two rooms - one small, one large; ideally, three rooms. The large room requires chairs (one for each participant) and 6 tables; The small room requires 10 chairs and 5 tables. Furniture must be movable.

PORTABILITY: All necessary game elements can be contained in a medium sized suitcase.

VERSION(S)/DATES: 1985 and 1988 versions of game reviewed with improved graphics.

MODEL CHARACTERISTICS: Highly complex model; five year time horizon.

Dimension: Gaming-Simulation with emphasis on gaming.

General Complexity: High interdependence between the decision variables, uncertainty in the decision situation and constraints on decision time.

Analytic Form: Primarily Heuristic
1. Value/Issue Clarification
2. Rational and Logical Exploration

Game Form: Extensive

Type: Rigid Rule - All rules specified and well defined in advance.

Game Solution: Cooperative - stresses high levels of communication, exploration of common interests and conflict. Stresses the concept of fair division, normative solutions suggesting how individuals should divide joint proceeds. Measures how much groups must be taxed or subsidized, i.e., so that it is possible to have both groups and social rationality satisfied simultaneously.

OVERALL EVALUATION:

Strengths: This gaming simulation is highly engaging and clearly illustrates the relationships between policy and planning at the national and local levels and the degree of success of a given project. Roles are clearly specified, the back-up documentation is well organized supporting ease of use for participants.

Weaknesses: The game is complicated to set up and run and therefore requires operators fully familiar with the model. Materials used in the game are simple but numerous, causing a complex environment to manage. The educational sector of the game is not fully developed.

GENERAL COMMENT: When the educational sector is completed, the game will be particularly useful to educational policy makers and planners for conveying an understanding of the ways that access and retention can be affected by demands on the population from health and agricultural sectors.

REVIEWED BY/DATE: Christina Rawley/April, 1988.

REVIEWER'S SOURCES: 6-hour (3 rounds) game run at Woodrow Wilson Centre for International Affairs, Princeton, New Jersey (February 20, 1988), written materials provided by the designers of the game, discussions with one designer.

APPENDIX 1.2

NAME:	**The Population and Development Game**
DESIGNER(S):	R. Scott Moreland
CITY, STATE, COUNTRY:	Research Triangle Park, North Carolina, USA
SPONSORING INST:	Population Branch, Department of Technical Cooperation and Development, United Nations
AVAILABILITY:	R. Scott Moreland, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709
PRICE/COPY/STATUS:	Free
CREATE/DEVELOP/DESIGN:	A several-month period equivalent to a six-week period
DEVELOPMENT COSTS:	$20,000
TRIAL EVAL DATE:	Field tested in the USSR, 1986
REVIEWS/PUB&DATE:	None
SUBJECT MATTER:	Population, education, employment and the economy in a developing country.

PURPOSE: For use as a training aid for use in courses in population and development planning to give players experience in using quantitative, computer-based planning tools. The simulation allows players to measure the impact of population policies on socio economic development factors. The model is driven by a supply side economic module that simulates the behavior of the major macro-economic aggregates, production, the balance of international trade, per capita income, manpower and development. A simulation is performed with the model's four modules where the results of one module feed into the other in the following order: (1) POPULATE (population), (2) EDUCATE (education), (3) ECON (macroeconomy) and (4) OBJECT (objective function). The sub- model EDUCATE is designed to project student enrollment in primary and secondary schools by using standard UNESCO grade transition model.

CONTEXT OF USE:	Designed to be used in training sessions; as part of a a 2-3 day workshop or course.
DATA SOURCE(S):	Based on the "accumulated experience of the Research Triangle Institute and Dr. Scott Moreland, Senior Economist."

TIME:	Maximum: 20 hours Minimum: 4 hours for module
INTENDED PLAYERS:	Professional policy analysts and planners
NO. OF PLAYERS:	1-20, 30
NO. OF OP(S):	Not specified in game documentation, but the game requires at least one operator.
QUAL. OF OP(S):	Necessary operator qualifications include knowledge of the technology, configuration of equipment, previous experience with the game.
TECH. & PHYS. REQ:	Hardware - IBM PC or compatible with 256K of ram, 2Mb of hard disk space and numeric coprocessor. Software - "Host" software shell.
PORTABILITY:	Game and data contained on six disks - highly portable between computer facilities.
VERSION(S)/DATES:	Original version and education module.
MODEL CHARACTERISTICS:	Principal sectors include population, education, macroeconomy including manpower and employment. Fifteen year time horizon.

Dimension: Simulation

General Complexity: Low interdependence among decision variables; no uncertainty in the decision situation and limited constraints on decision time.

Analytic Form: Primarlily Algorithmic - Simulates description, classification, analysis, forecast and looks for optimal conditions.

Game Form: Extensive - every possible choice is represented in the model.

Type: Rigid Rule

Game Solution: Noncooperative or Cooperative.
Noncooperative - stresses individual rational behavior. Players compete against each other by individually controlling all decision variables. The game organizer unilaterally imposes a set of constraints or conditions. Competition takes place on the basis of the socio-economic performance outputs of

the simulation model.

Cooperative - stresses communication among groups playing the simulation and the objective is to maximize the performance of the socio-economic system as defined by the game's objective function.

Performance in the game can be measured by an objective function which allows players to compare the results of their decisions' impacts on the game's multiple performance criteria. The weight attached to the various performance variables can be decided upon at the outset of play by either the Instructor or jointly by the players through a group discussion. The changeable weights allows for alternate interpretations of what constitutes a "successful" development policy. These weights are fixed throughout the use of the game.

Cobb-Douglas Utility function allows scenarios to also be scored according to configurations of weights to allow discussion of the way in which different policies appear to perform vis-a-vis different goals.

OVERALL EVALUATION:

This simulation provides a useful exercise for use within a training program in conjunction with HOST. It provides planners and policy makers experience using computer tools and a data set that can be manipulated in various ways to demonstrate the connections between several parts of the socio-economic system.

The general ease of use and learning are related to the specific requirements of the computer system and the software. It is assumed that the players are planners and statisticians from developing countries with a university level education in economics, demography, and statistics and some training in the use of microcomputers and planning techniques. Without this level of knowledge, it will be difficult to participate in the simulation without a high degree of frustration.

The documentation for the simulation is substantial and highly technical. The original manual contained over 40 pages of data tables. Later manuals written for players and instructors contain fewer tables, yet of the 28-page players' manual, 16 pages are devoted to tables; the 19-page instructors' manual contains 5 pages of equations and a 5-page listing of variables.

Degree of participant interaction is limited. Interaction is affected by the highly technical orientation of the simulation. Scenarios, roles, goals and time constraints are not fully developed in the

documentation to encourage participant interaction and the heuristic qualities of a game.

Degree of operator-dependence is high because the documenation and scenarios are not developed.

GENERAL COMMENT:	This simulation is useful for educational planning and policy makers who are well educated in the use of computer technology and with an strong background and experience in planning, economics and statistics. The simulation offers experience in working with large data sets.
REVIEWED BY/DATE:	C.C. Rawley - April 30, 1988
REVIEWER'S SOURCES:	Review compiled from interviews and a demonstration by the designer, supporting descriptive literature on the game, observations a four-hour run of the education module at the Harvard Graduate School of Education, Project BRIDGES training course for policy makers and planners from Ministries of Education in Developing Countries in August, 1987 and results of a questionnaire administered to game participants at that time.

APPENDIX 1.3

NAME:	**Perform**
DESIGNER(S):	Jan Klabbers
CITY, STATE, COUNTRY:	Utrecht, Netherlands
SPONSORING INST:	Ministry of Education and 13 Dutch universities
AVAILABILITY:	Jan Klabbers, Faculty of Social Sciences, P.O. Box 80140, 3508 TC, Utrecht.
PRICE/COPY/STATUS:	Not available at this time
CREATE/DEVELOP/DESIGN:	June 1981 - 1983.
COSTS:	Initial start-up and development costs were $400,000 (including development of FORMASY manpower planning model, 2 full-time researchers). Costs of revised versions (board game and MacIntosh) not available.
TRIAL EVAL DATE:	Fall-Winter, 1983 within universities and Ministry of Education in Utrecht.
REVIEWS/PUB&DATE:	None to date.
SUBJECT MATTER:	Manpower planning and policy formulation - number of personnel, distribution over ranks and age, salaries.
PURPOSE:	This model addresses problems of university management in a changing environment - the transformation and growth of Dutch universities from small-scale traditional teaching institutes to complex large-scale "knowledge industries" during a period of decreasing budgets.
CONTEXT OF USE:	Operational use within training programs at (1) the ministerial level (2) the university level and (3) the departmental level of planning and policymaking or as a freestanding simulation.
DATA SOURCE(S):	Game is based on empirical research, personal experiences, official documents, actual statistical data from two departments.
TIME:	Computerized versions are eight hours (mainframe version); 4-8 hours (mini-computer version);

non-computerized boardgame version requires a 4-hour session.

INTENDED PLAYERS: Administrators and planners of universities and by public officials of the government

NO. OF PLAYERS: 10 (Minimum); 20-25 (Maximum).

NO. OF OP(S): Two operators (mainframe or micro-computer version); no operators (MacIntosh version)

QUAL. OF OP(S): One operator with knowledge of computer system; no operators with MacIntosh version).

TECH. & PHYS. REQ: FORMASY manpower planning software and PERFORM Game originally required a mainframe; Conversion I requires one computer with 10 Mb, VAX system for use with mini-computers (IBM or Digital); completion of Conversion II to Macintosh will require 1 Macintosh II, a Mac SE for use as a mailbox and an SE for each faculty group.

PORTABILITY: Software on Versions I and II is portable; board game easily portable.

VERSION(S)/DATES: Review compiled with designer's descriptive literature: "Design characteristics of the simulation/game PERFORM." Paper presented at the fifth European Forum of the Association for Institutional Research August, 17-19, University of Limburg, Maastricht, the Netherlands.

MODEL CHARACTERISTICS: Simple models, close to practitioner's insights and experiences, based on three main characteristics of (1) rank, grade or function, (2) grade-age, (3) age.

Dimensions: Gaming-Simulation

Complexity: High amount of interdependence between the decision variables, uncertainty in the decision situation and constraints on decision time.

Analytic Form:

Boardgame - Heuristic

1. Value/Issue Clarification
2. Rational and Logical Exploration
3. Expert Systems

Other versions balanced between heuristic and algorithmic.

Game Form:

Characteristic Function - Decisions are made by more than two parties and can be made outside the context of the actual game to reach jointly optimal outcome.

Type: Rigid Rule - Each session progresses through a previously defined sequence of steps. During each step, the groups of players, board, council, and planners act according to rules described int he role descriptions.

Game Solution:
Cooperative - stresses high levels of communication. PERFORM is used with the computerized planning system, FORMASY allows for "conversational planning." Final resolution of the game lies in the set of outcomes within the core, stressing the power of groups. Stresses the concept of fair division, normative solutions suggesting how individuals should divide joint proceeds.

OVERALL EVALUATION:

The strength of PERFORM lies in the compatability of the computer software with the game. Design requirements included:

*No technicalities for users. Tools can be used by staff members from the personnel-and-planning-staffs who have no mathematical training or knowledge about computer programming;

*No built-in decision algorithms. Optimization algoritnms were not considered feasible because constraints and objectives are rather ambiguous and equivocal with respect to manpower planning at universities.

*Visibility of the policymaking structure showing different aims and policy instruments at distinct levels.

*Portability of models and computer programs, combined with flexibility for future adjustments.

GENERAL COMMENT: FORMASY and PERFORM are "frame instruments" that can be loaded with various specific models and used to track consequences of policy options and impacts with respect to number and distribution over ranks, age and costs of personnel useful for planners and policy makers in higher education in a variety of contexts.

REVIEWED BY/DATE: C. Rawley

REVIEWER'S SOURCES: Interview with game designer & source documents.

Appendix 2: A SELECTED LIST OF GAMING SIMULATIONS AND SPONSORS

The Simulated Nutrition Game (SNUS) was designed for the Food and Agriculture Organization (FAO), Rome. The objective of this interactive simulation game is to familiarize national planning teams of Third World countries with the impact of various policies, both manufacturing and non-manufacturing sectors, on national nutritional planning. (Duke, 1981)

The Human Settlement Management Game (HEX) was designed for the United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris for use in a workshop on the training of human settlement managers organized by the University of Science and Technology at Kumasi and the Tema Development Corporation of Ghana. The objective of this game is to encourage a candid discussion of the problems of communication, horizontal and vertical, in national planning. (Duke, 1981)

The Chase Manhattan Bank 1985-1990 Game was developed for Chase Manhattan Bank, New York. The objective of this game is to allow executives to evaluate development strategies for the International Division in a 1985-1990 window. (Duke, 1981)

Strategem I, designed under USAID contract at the Center for Resource Policy, Dartmouth, New Hampshire for use in Costa Rica to demonstrate the relationships and overall effects of policy decisions made at the national level by ministries of trade, energy, environment. This game has subsequently been used ten other countries, including Hungary, The USSR and Tanzania. Meadows (1985)

UNTODES, the United Nations Tourism Development Simulation (Paris: UNESCO, 1969) was developed to help local officials evaluate and plan for a variety of tourist-oriented developments in Sicily.(Dandekar and Feldt, 1984)

The Community Land Use Game CLUG, was developed for use in helping the citizens of Bariloche, Argentina to better visualize and understand the impact of different planning options for their city.(Feldt, 1984)

The Population and Development Game was developed for the Population Branch, Department of Technical Cooperation and Development, United Nations. This game is designed to give players experience in making public policy and planning decisions in the areas of population, education, employment, and the economy. (Moreland, 1986)

Perform and Formasy were developed for the Ministry of Education and Sciences by the University of Utrecht for manpower planning for universities in the Netherlands. (Klabbers, 1985) It consists of a manpower planning model embedded in an interactive gaming simulation.

CAPJEFOS was also developed for UNESCO -- Buea, Cameroon, for the purpose of illustrating the delicate relationships involved between development agents and the inhabitants of a small African village. Greenblat, 1986)

Bafa Bafa was developed by Western Behavioral Sciences Institute, La Jolla, California, for use by the Extension Gaming Service at Michigan in a program to prepare Peace Corps Trainees for work in developing countries.(Dandekar and Feldt, 1984)

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1. Introductory reading
2. Game and Simulation Design
3. Game and Simulation Evaluation
4. Economics
5. Inernational Relations
6. Business and Management Relations