Problems in the Structure and Use of Educational Simulation*

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Despite a burgeoning array of educational simulations, developments in this area have not been guided by much in the way of clear pedagogical criteria. Such criteria are needed to facilitate comparative evaluations of existing simulations and to promote their effective use, as well as to guide future developments. Pursuant to the delineation of such criteria, a number of structural desiderata and factors contributing to the effective use of instructional simulation are identified and discussed. Attention also is given to the role of learning objectives and how they relate to the design and use of simulation exercises.

During the past decade, we have witnessed an amazing proliferation of simulations designed exclusively or in part for the purposes of education (for example, see Teaching Research, 1967; Klietsch et al., 1969; Zuckerman and Horn, 1970). The scope of these activities now encompasses nearly every academic discipline and extends to all levels of instruction. These trends seem likely to continue, although perhaps at a somewhat abated rate as the novelty wears off and gaming becomes less faddish. In any case, we probably can expect both a growing repertory of educa-

* Practitioners of simulation and gaming differ in their use of terminology. Some argue that all games are simulations, but not all simulations are games. For these persons, the distinction between simulations and games rests on the type of structure involved and the purpose for which that structure is used. Others discriminate on the basis of content, arguing that all simulations are games, but not all games are simulations. Thus, it is possible to speak of "simulation games" and "non-simulation games," the latter being contrived activities that have no external referents. Here, the terms simulation and game will be used interchangeably to refer to activities designed as analogues of referent processes. These activities will involve student participation and are explicitly intended to provide instruction regarding the referent processes.

1 The editors of Social Education, which provides fairly regular information on simulation and gaming, reported in 1969 that they received more articles on this subject than on any other (38, February, 1969:176). New developments also are reported regularly in Simulation and Games, a journal created explicitly for this purpose.
tional simulations and new and more extensive applications of gaming techniques.

While the use of instructional simulation has become more pervasive, developments in the area have not been guided by much in the way of explicit pedagogical criteria. Despite more than a decade of experience with these techniques, relatively little attention has been given to the question of what makes for an effective simulation exercise. Interestingly, there has been considerable discussion of the relative merits of simulation vis-a-vis other modes of instruction (for example, see Abt, 1970; Alger, 1963:150–189; Brown, 1969:41–43; Coleman, 1966:3–4; 1967:69–70; Kraft, 1967:71–72; Raser, 1969; and Snyder, 1963:1–23); but little consideration has been given to the relative merits of one simulation versus another. In a sense, the latter question is logically prior to the former. In the absence of any criteria (save one's gut reaction) for comparing educational games, the question of the value of simulation relative to other instructional techniques seems a bit premature and meaningful only in the abstract. More immediately, the lack of comparative criteria means that there is little in the way of useful guidelines to direct future developments in the area and to promote the effective use of existing games.

Surely, there are lessons to be drawn from the experience that has accumulated over the past decade. These lessons could help in providing the comparative criteria that are needed. Certainly, the variety of existing games and the range of their application is sufficiently broad to afford some perspective on the factors that contribute to their relative effectiveness as educational vehicles. This paper represents an attempt to identify some of these factors and thus to specify some of the major burdens that the designers and users of educational simulations must bear.

The instructional value of a simulation is largely a function of three partially interdependent factors: (1) content, (2) structure, and (3) implementation. Because it is difficult to generalize about content, primary attention will be given here to the problems of the structure and use of educational games. In general, it will be presumed that the designer or user knows what he wants to convey via the exercise. We will be concerned primarily with how that content can be conveyed most effectively. In this context, considerable attention will be given to the role of learning objectives and how they relate to the design and use of gaming exercises.

While it is difficult to talk about learning objectives in the abstract, it is a subject too vital to be overlooked. Simulation is purposive activity; but without explication, such a statement is largely meaningless. In the absence of explicit learning objectives,
it is impossible to assess or evaluate either the appropriateness or the effectiveness of the technique. Moreover, without such learning objectives, the whole enterprise is likely to be found an aimless venture by all involved.

**STRUCTURAL DESIDERATA IN EDUCATIONAL SIMULATIONS**

Broadly speaking, instruction may be divided into two general types: (1) training and teaching specific skills and facts and (2) teaching general principles, concepts, and orientations. Although any given period of instruction might not fit neatly into either one of these categories, as one moves up the educational ladder emphasis tends to shift from the former to the latter type of instruction. Simulations can be and have been used in both areas. For present purposes, the important point is that the difficulties in both the design and use of simulation exercises increase enormously as one moves from training to more generalized education. As a general rule, the more narrow the problem, the more manageable it is; the more manageable the problem, the easier it is to game. As the scope and complexity of the problem increase, focus becomes more difficult, crucial variables harder to identify, relationships blurred, and our knowledge more sparse.

In training situations, one normally has a rather clear idea of what he wants to convey and fairly firm control over what is conveyed and how well. In short, for most training problems, there are “textbook answers” making criteria for instruction and evaluation less difficult to define and implement. As a result of training, the student is to be able to perform a specific task in a specific manner. The educator’s task is simply to find the most effective training vehicle (in terms of performance level, costs, and time—both his and the student’s). In some cases, such as the training of prospective pilots, simulations, e.g., flight simulators, have abundant and fairly obvious advantages over alternative modes of training. In other cases, e.g., training police officers in the prevention and control of civil disorder, the potential advantages of simulation are clear but perhaps less compelling from a costs-benefits point of view. In any case, practical training exercises in the form of simulations are fairly easy to develop and use.

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2 This problem is not peculiar to simulation and gaming. It is a problem that has received insufficient attention with respect to almost all educational techniques (e.g., lectures, discussion, case studies). Perhaps this is one reason why research has been so inconclusive regarding what constitutes a good teacher, method, etc. and what the relative effectiveness of different methods is in different situations and with different subject matter. See Boocock, 1966:1–45.

3 This distinction roughly reflects the distinction Boocock makes between “cognitive learning”—the acquisition of some new body of information—and “non-cognitive learning”—a shift in values, attitudes, interests, or motivation (1966:2).
As one moves to the teaching of general principles, simulations tend to become less practical exercises and more dynamic case material to supplement other materials and modes of instruction. Problems of design and effective utilization increase as do the critical capabilities and inclinations of the students. There are no quick and easy solutions to these problems. It is possible, however, to identify certain desiderata in the way an educational simulation is structured. To some extent, the desired characteristics or structural properties are mutually competing. Nonetheless, they point to critical areas that must be considered in the basic design and construction of the exercise, if it is to be an effective educational tool. While the burden posed by these structural questions rests heavily on the designer, they are also crucial considerations to be weighed carefully by the potential user in selecting from existing simulation exercises.

**Credibility**

Just as validity is the *sine quo non* of theory, it is the ultimate and overriding requisite for simulations used for research and policy guidance. In educational simulations, however, it is not so much validity but credibility that is the primary requisite. In fact, to a large extent, credibility provides the *raison d'être* for educational gaming.

Assuming by validity that we mean a demonstrable pattern of correspondence between simulate or game processes and observable referent processes, it might seem that validity and credibility are perfectly compatible and that validity would be the best assurance of credibility. This, however, is not necessarily the case. Validity and credibility constitute distinct evaluative criteria and may at times actually be contradictory. Validity is predicated upon external standards (viz., the referent or object system being

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Most definitions center on the degree of correspondence between referent and simulate processes and how these are to be assessed. Isomorphism, or a one-to-one correspondence, is not necessarily required for the validity criterion to be met. Herrmann (1967:219) suggests that what I am calling credibility may be considered one of many validity criteria, the appropriateness of any one being determined by the purpose for which the simulation is constructed. Herrmann further identifies "face validity" as a possible criterion. Here surface or initial impressions of a game's "realism" are used to assess validity. It seems preferable, however, to distinguish validity and credibility, since they are predicated on different standards, the former supposedly on objective assessments of a detached observer, the latter on the subjective reactions of participants. This seems to be the tack taken by Barton (1970:58) when he speaks of "verisimilitude" in man-machine simulations and by Abt (1970:114-115) when he talks of "realism" in serious games. Also see Kardatzke (1969:179-180).
simulated) and is independent of the participants in the synthetic system created by the simulation. Assessments of validity are appropriately made by a detached observer. Credibility, on the other hand, is dependent upon the participants and their perceptions and reactions to the game. Thus, we would heartily agree with Hermann (1967:219) when he suggests that in instructional simulations the primary evaluate criteria shifts "from the observable universe to the effects on the cognitive and affective systems of those individuals which the operating model is intended to instruct." Credibility is not, however, simply a matter of ex post facto assessment; rather it must be a consideration that is built into the very structure of the exercise.

To insure credibility, the designer and user of an educational simulation must take cognizance of the experience and capabilities of the student-participants. Ideally, a simulation will allow students to draw upon and to extrapolate from their experience or knowledge. The realism and relevance of the exercise thus will be readily apparent. Unless the game allows the student to relate referent experience or knowledge, it will be exceedingly difficult for him to adjust to the synthetic environment created by the simulation. If the purpose of the exercise is to convey poignantly the meaning of "culture shock," this is fine; but otherwise, it will be destructive to the intended learning objectives.

The requisite credibility, of course, is intertwined inextricably with the learning objectives of the exercise. To forcefully and effectively convey a lesson, it may be necessary artificially to isolate certain processes and to exaggerate, simplify, or otherwise distort them. The presumption is that in general one knows the points that he wants to make and is using simulation to convey these points in an experiential way. As long as the contrived situation remains plausible and reasonable within the student's frame of reference, such distortion will not adversely affect the credibility of the game.

Unnecessary abstraction of structures and processes that exist (or are assumed to exist) in the referent or object system, as well as the introduction of game specific terminology and jargon, will tend to reduce credibility. Both are to be avoided. While simulation may be used to encourage students to view complex systems from an abstract or theoretical point of view (see, Alger, 1963:162 and Verba, 1964:494), this is best accomplished by incorporating concepts and variables of general applicability rather than game specific ones.

Symmetry

What the participants learn from a simulation exercise is necessarily tied to their experience in that simulation. The more
diverse and diffuse the experience of the participants, the more heterogeneous and uncertain the learning will be. It is not surprising then that simulations which place different students in structurally different situations and expose them to markedly different stimuli tend to produce mixed results in terms of student learning (for example, see Boocock and Coleman, 1966:229 and Cohen et al., 1964:263–264). If a simulation is used as a vehicle to achieve certain learning objectives, it seems only reasonable to provide the students with a common experience consonant with those objectives—common in the sense of coping with the same variables, relationships, parameters, and starting conditions. Simulations which place student-participants in different types of roles and/or in different types of decisional units create an asymmetry of experience that parallels the asymmetry of the game. Many of the more widely known simulations and games suffer to varying extents from such asymmetry (for example, see Guetzkow and Cherryholmes, 1966; Industrial College of the Armed Forces, 1969b; Cohen et al., 1964; Scott, 1966; Thorelli and Graves, 1964; and Weinbaum and Gold, 1969).

Symmetry in the structure of a game facilitates the accomplishment of the learning objectives desired of it. Unless this symmetry is built-in, iteration of the game with a reassignment of roles each cycle is perhaps the only way to achieve some symmetry of experience. To some extent, structural symmetry may fly in the face of the need for realism. However, a number of games have managed to treat this problem quite successfully (examples include Coplin et al., 1971; Summit, 1961; and Industrial College of the Armed Forces, 1969a; 1970). Asymmetry becomes most troublesome in complex, more comprehensive simulations, suggesting that from an educational point of view, simpler and more limited games may be desirable (for example, see Coplin, 1970:412–426 and Stitelman and Coplin, 1969).

Synchronization

Another problem that often becomes acute, particularly in more complex and comprehensive games, is the problem of asynchronization. One of the virtues of simulation is that it allows for the condensation of time. However, in complex games, multiple time frames may be introduced that operate simultaneously but call for different reckoning scales, i.e., there are different scales for converting to real time. A certain amount of asynchronization is probably inevitable, since human participants will always be thinking in real time while the events of the simulation may be preceding along a generally condensed but largely arbitrary game time. However, when interactive elements are added
wherein members of participant teams are allowed to interact, negotiate, and bargain with one another on a face-to-face basis, yet another time frame is introduced.

This asynchronization is further compounded by the fact that the distortions in time will not be experienced uniformly by all participants. This gives rise to a confusing type of temporal asymmetry wherein some participants may be operating in one time frame, while others are acting in quite a different time-reckoning system, neither of which may be in-tune with the relentless beat of the clock used in the administration of the game. Thus, the problems of asynchronization are particularly acute in any simulation involving sequential dependence and dynamic change geared to a specific time schedule.\(^6\)

The problem of time is indeed a perplexing one; and as Guetzkow (1963:148) observed some years ago, it is a problem that deserves much closer attention. One thing seems clear, as asynchronization increases, the credibility of the game is diminished and frustration quickly can replace learning. Ideally, a simulation should have a single referent time span and uniform time-reckoning, i.e., equivalent conversion ratios for all simulated activities. This means that in some way the designer and user must attempt to reconcile game emergent time with the structured time frame of the game periods and make sure that both of these are compatible with the real time required for the mental operations of the participants.

This does not mean that condensation of time is impossible or that the simulated time frame must be consonant with real time. Rather, it simply means that the demands placed on the student-participants must be consonant with the temporal constraints imposed by the game. There are a variety of ways of reducing the synchronization problem. Perhaps the most obvious is to restrict the scope of activities being simulated to those that are amenable to uniform time-reckoning. This logic may be extrapolated readily to more complex games that are broader in scope by simply sequentially segmenting activities such that there is uniform time-reckoning within game periods (or segments thereof) but not necessarily across periods. While the credibility of exercises that encompass activities that are not sequentially dependent upon one another may suffer from this strategy, it has been employed quite successfully in simulations that involve activities that have an inherent chronology (examples include the Aerospace Business Environment Simulator and the Defense Management Simulation).

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\(^6\) These problems are fairly common in simulations like the World Politics Simulation (Industrial College of the Armed Forces, 1969b).
Because asynchronizations tend to be most acute in games where there are multiple decision-making units (be they teams or individuals) that are allowed to interact on a face-to-face basis, the problem may be mitigated by reducing the number of teams to two or by proscribing face-to-face interaction. Prohibiting face-to-face communication and bargaining does not necessarily preclude the inclusion of important interactive elements in the exercise. Interaction can be programmed into the structure of the game by making the results of decisions made by different participants interdependent (see Barton, 1970:56; the Management Decisionmaking Exercise is an example of this type of simulation). This procedure allows (and may even promote) tacit bargaining and communication, while constraining the degree of asynchronization that can develop.

**Manageability**

That simulations can place students in relatively complex environments is surely an advantage. Such complexity can afford challenging experience that fosters an appreciation of the interdependence of various processes and the interface of multiple problems. Because of this, simulation can provide a more integrated or holistic view of phenomena than is generally possible through other educational techniques. Such complexity will be counter-productive, however, if it is more an artifact of the game than a reflection of the phenomenal complexity being simulated. A good example of such complexity (or perhaps it should be called complication) is the proliferation of forms that characterizes so many simulations. The student-participant literally can be overwhelmed by paper and paper work that bears little relevance to the main objectives of the game. Understandably, this can lead to great frustration.

Elaborate and complex games also can inhibit learning by obscuring cause and effect relationships. If it is difficult or impossible for the student to see the impact of the decisions he makes or if this impact is remote or miniscule in comparison to that of other variables over which he has no control, the feedback that he gets is unlikely to have much learning impact. This is one of the problems that has limited the value of TEMPER as an instructional exercise (see Industrial College of the Armed Forces, 1968). Similarly, learning may be impeded, if the student is forced to make so many decisions and to cope with so many facets of a game simultaneously that he has no time to analyze, deliberate upon, and think through his decisions. His behavior in such circumstances will be predictably nonsystematic, and his experience largely unrewarding.
The problem of manageability essentially means that the task that a student is asked to perform at any point in time must be limited but consequential to the outcome of the exercise (see Abt, 1970:112–118). The factors that the student is to consider and the decisions he is to make should bear a direct relationship to the learning objectives established for the exercise. Busy work and tangential activity dilute the learning impact and obscure the purpose of participation.

If the learning objectives established for a game are multiple and sufficiently ambitious to require an elaborate and fairly complex environment, manageability perhaps can be achieved most readily through a progressively developing simulation. Here new elements are introduced and the environment changed or enriched as the game proceeds. This allows the student to see the effect of increasing complexity while preserving specific relational lessons. It also enables him to cope more effectively with complexity through progressive mastery of component aspects of the simulated environment.

Progressively developing simulations may take one of two forms: (1) one built up from a simplified situation which is gradually compounded by additional elements that add new dimensions to the original problem (see Sachs, 1970:165) or (2) one which is segmented and sequenced so that a problem is dealt with in a piecemeal fashion in a manner consonant with the life cycle of the problem. The decomposition and re-integration of situations through simulations of the first variety are somewhat artificial, but nonetheless this can be a potent way of conveying information. Simulations of the second variety may be segmented in a more realistic way but presume that the problem being simulated has itself a natural life-cycle, e.g., the development and production of a specific product.

Another way in which a simulation exercise can be made more manageable (and thus more comprehensible to the student) is through provision for student interrogation of the model, i.e., exploration of the synthetic environment created by the simulation. Such interrogation will not only enable the student to make reasonable projections of the consequences of his decisions, but more importantly it will allow him to find a degree of predictability in the synthetic environment that is essential for meaningful action.

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6 The Defense Management Simulation is structured in this way (Industrial College of the Armed Forces, 1970).
7 The Management Decisionmaking Exercise (Industrial College of the Armed Forces, 1969a) provides this capability through remote, time-share computer facilities. While computers may be used, interrogation need not be via a computer. It may be accomplished through written or verbal messages between participants and game administrators.
On-line exploration (i.e., exploration occurring during the game) of the simulated environment also speaks to another perennial problem in instructional simulation; namely, the problem of acclimating students to the artificial environment created by the simulation. The time spent in getting the student attuned to the environment in which he must operate is a kind of overhead and is largely a waste in terms of specific learning objectives. This time can be reduced by providing the student with additional vehicles for familiarizing himself with the simulated environment and allowing him to explore it further as the game proceeds.

The primary purpose of such interrogative vehicles should be to provide the participant with only that information he reasonably could expect to be available in a referent type of situation. While most simulations are designed as exercises in decision-making under uncertainty, that uncertainty should be bounded. Insofar as the uncertainty under which the student must operate is merely an artifact of the game, it is destructive to its educational purpose.

In most decision-making situations, search activities are an important part of the overall process. Providing students with the capability of interrogating the model and exploring the game environment thus has the additional advantage of allowing this vital aspect of the decision-making process to be incorporated into the structure of the simulation. Thus, it can serve to promote the analytic and decisional skills of the student-participants by encouraging planning, deliberation, and anticipation.

**Ease of Administration**

Just as simulations can become so complicated and involved that they are unmanageable for the participants, they can become impossible to administer. Unless the game administrator can keep up with and coordinate the flow of events, the exercise will disintegrate, the students will become frustrated, and the game will degenerate into an exercise in futility. The demands on the administrator must be minimized. Generally, the more manageable a game from the participant's point of view, the easier it is to administer. Many of the things that facilitate manageability also will facilitate administration of the game, e.g., the fewer the game forms the participants have to work with, the fewer the administrator will have to worry about. In addition, the use of computers to perform involved, tedious, or lengthy calculations and collation will aid the administrator greatly. The use of remote, desk-type time-sharing terminals is particularly advantageous.
They not only facilitate the effective and accurate administration of the game through quick and almost continuous access, but they also make feedback processes to the students more rapid and thus help to insure the continuity of the exercise. In general, the use of computers allows the simulation to be richer and more "realistic" (i.e., more credible) without placing additional or unnecessary burdens on either the students or the administrating faculty.

More Continuous Decisional and Feedback Processes

Reflecting in part the state of the art, expediency, and the facilities that were available when educational simulation first began to be used, most simulation exercises are broken into arbitrary playing periods with actual decisions coming at a single point in time. Such point decisions and point feedback often belie the dynamics of referent processes, detract from the credibility of the exercise, and contribute to the asynchronization and unmanageability that is so frustrating to the student-participants. As the end of a period approaches, there typically is a mad rush to meet arbitrary deadlines. Considerations of priorities, logical sequence, and relationships, along with any deliberative processes, give way to the relentless demands of the game clock. While time-pressure may be a variable that one wants his students to come to appreciate, it is doubtful that arbitrary deadlines will foster an appreciation of anything but the "non-reality" of the game or simulation.

Insofar as possible, deadlines should flow logically from the sequence of activities or events being simulated. Decisional and feedback processes should be both logical and continuous. The student should not be left to operate in an informational void and forced to make a series of decisions without the benefit of the kind of prior information that a person in an analogous referent situation reasonably could expect to have. Yet point decisions and point feedback tend to place the student in this very position.

To some extent, the problem is mitigated by provision for student interrogation and exploration of the model. However, this is only a step in the right direction. With the computer capabilities currently available, there is no reason why we should be satisfied with the discrete, punctuated time-slicing and halting decision-making and feedback processes that always have characterized educational gaming. More continuous simulations, wherein the participants make decisions and get feedback more like they could expect in a referent situation, would allow us to do greater justice to the avowed claim of revealing to students the dynamics of the referent process or system.
EFFECTIVE USE OF EDUCATIONAL SIMULATIONS AND GAMES

In addition to the variety of structural problems that can detract from the effectiveness of educational simulations, there is a whole array of problems that the user can create for himself. By resorting to a variety of expedients, the most enthusiastic advocates of instructional simulation at times have imperiled the success of their own cause.

Innovation without Oversell

The inertia present in any institution makes the introduction of anything new and unfamiliar difficult. This problem is particularly acute in the case of instructional simulation, especially if computers are involved. Considerable skepticism continues to surround the use of simulation to say nothing of the problems of fitting new costs into already tight budgets. Confronted with these challenges, there is perhaps a natural tendency for the proponents of innovation in this area to resort to exaggerated claims and promises. Inordinate claims and promises, however, can breed disillusionment (among both students and administrative authorities) and can come back to haunt, if not destroy, a genuinely productive but less than spectacular effort.

Simulation is not (and should not be promoted or embraced as) a panacea for the ills of education. It is simply another method in the repertory of methodologies available to the educator. There is little hard evidence to suggest that, in general, educational gaming is any more or less effective than other teaching methodologies, all of which have their own strengths and weaknesses (see Robinson et al., 1966:53–65; Boocock and Coleman, 1966:215–236; Cherryholmes, 1967:4–7; Boocock, 1968:107–133; Baker, 1968:135–142; Wing, 1968:155–165; Fletcher, 1971:259–286; and Lee and O'Leary, 1971:309–347). Impressionistic evidence strongly does suggest that for certain purposes, simulation may be more useful than other educational methods (see Abt, 1970:61–78); but by the same token, there are undoubtedly many instances where it is less appropriate.

The decision on which method will be employed is one the educator cannot escape. It must rest on considerations of time, facilities, staff assistance, and most importantly, the objectives of the instruction. In most circumstances, a mixed strategy probably is the most appropriate (Deutsch and Senghas, 1970:37–40). Not least of the potential advantages of educational simulation is the interest and enthusiasm it can generate among students.
This can do much to relieve the tedium often associated with more conventional modes of instruction.

**Accurate Estimation of the Costs Involved**

Just as advocates of simulation at times have been guilty of exaggerated claims and promises, they also have tended to underestimate the time, effort, and material costs required for the effective use of these techniques (see Shubik, 1968:629–660; Cohen, 1962:367–380). This again is to invite disillusionment. Interestingly, even those persons and institutions that conduct instructional games regularly have tended to play down these requirements. A smoothly operated and effectively administered simulation may belie the enormous amounts of time, energy, and effort that must be devoted to its preparation and conduct. While perhaps a tribute to the modesty and effectiveness of the user, it can be most deceiving to the unwary observer.

The costs of simulation in both time and money are not easy to calculate. Both types of costs have several dimensions. With respect to direct dollar expenditures, things like the costs of publishing game materials and the costs of computer time readily come to mind. This sort of accounting can be misleading, however. A game that can be conducted at one institution for a relatively modest sum might cost another many times that, owing to the disparity in assistance and facilities available to one user and not the other or to the costs of converting a computer program to make it compatible with a different machine.

With respect to time, one's cost calculations must include not only the time required to conduct the exercise but also the enormous amounts of time required to prepare the materials and set up the exercise, the time spent in learning to administer the game (or to train others to do it), the time spent to orient the student-participants, and the time the students themselves have to spend simply in learning the mechanics of the game. When all of these time expenditures are added up, we are talking about a considerable number of man-hours that must be put in before even the simplest game can start.

In mentioning these cost considerations, my intent is not to discourage the use of educational simulation and gaming. These are simply problems that must be reckoned with. Simulation and gaming can be an expensive enterprise, but there are ways of economizing in terms of both time and money. Careful design and discriminating use of simulation exercises can reduce the preparation time required of both the students and administering faculty. Mutual cooperation among institutions and the sharing of facilities also can reduce costs and staff requirements.
Integration into Broader Educational Experience

While novelty is perhaps one of the most appealing characteristics of simulation, it should not be viewed as a complete and independent form of instruction. It cannot stand alone. Simulation may be used to summarize, integrate, and illuminate previous instruction or to provide a common experience for reference in subsequent instruction. Without other instruction, however, participation in a simulation is an incomplete learning experience. For effective utilization, simulation must be meshed with other modes of instruction and integrated into the student's larger educational experience. Simulation is most effective when it is an integral part of a multi-faceted and mutually supporting educational strategy.8

A number of implications flow from this. First, adjustments must be made not only in a proposed simulation but also in the curriculum or course that it is intended to support. Second, the enthusiastic support of other faculty members is likely to be needed. These persons should be thoroughly familiar with the exercise and have a firm understanding of the formal model or core assumptions upon which the exercise is predicated. Third, both the user and cooperating faculty must be prepared to point out the lessons to be drawn from the synthetic experience provided through the simulation and to show how these lessons may be linked to other instruction. Facts, be they real or synthetic, do not speak for themselves. Thus, without assistance, a student may fail to perceive or appreciate the larger implications of his experience. Clearly articulated learning objectives, a good orientation, and a thorough post-game review will aid immeasurably in getting the most out of a simulation, particularly when it is linked to other instruction.

Appropriate Substantive Qualifications and Precautions

Just as students are sometimes inclined to mistake written words for truth, there is sometimes a tendency for the neophyte to assume that simulations, particularly computer-assisted ones, embody proven principles and sound knowledge. While this may be a tribute to the credibility of an exercise, it is a sadly mistaken assumption. Most simulations, particularly those designed to simulate broad social or economic processes, often are predicated

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8 The use of the Aerospace Business Environment Simulator (Summit, 1961) in courses in the School of Business at the University of Utah provides a compelling example of the use of this strategy.
on little more than informed hunches. Moreover, it is often difficult, especially in large scale games, to control the sort of impressions that the students extract from their experience. Clearly, one can mislearn as well as learn from an instructional game (Smoker, 1972:322). Insofar as a game reinforces questionable or erroneous assumptions or serves as a "mechanization of popular mythology adding to it a dollop of scientism" (Shubik, 1968:635), it is clearly counter-productive to the educational enterprise.

To avoid these dangers, it is important that faculty and students alike appreciate that the simulation of phenomena does not transform ignorance into knowledge. To foster this appreciation, the students should be invited to study and discuss the formal model or assumptions upon which a game is based (Deutsch and Senghaas, 1970:39-40). If at all possible, they should be encouraged to grapple with the problems of model design and improvement. Perhaps this can best be accomplished by having them design and exercise small models of their own (Sachs, 1970:164). However it is accomplished, it is vital that students become aware that simulation models are neither substantively neutral nor necessarily based on more than highly tentative assertions.

**Definition and Implementation of Specific Learning Objectives**

Generally speaking, educational simulations are not conducted simply for the sake of simulating. A residual objective may be to familiarize students with the technique, but the primary objectives are likely to be more substantive. In articulating these objectives, a statement of the general learning potentials attributable to the technique is a frequent but unsatisfactory substitute for a statement of the specific purposes of participation in the exercise.

The learning objectives associated with a simulation exercise should be sufficiently clear and specific to provide meaningful guidance to the student-participants. These objectives should be made clear at the outset and dwelt upon during the initial orientation. The post-game review should be structured around these objectives, which may be discussed in light of the simulation experience. Without the discipline imposed by such specific learning objectives, the results of the exercise are likely to be nebulous and disquieting no matter how well it is structured and administered.
STUDENT-ORIENTED LEARNING OBJECTIVES

Before asking how a student learns from an educational simulation, we must be able to answer the question of what is to be learned. In fact, this question is logically prior to the questions of structural design (or selection) of a gaming exercise. Properly defined learning objectives can provide valuable guidance for the designer and prospective users of an instructional game. They also aid students as they prepare for and participate in the exercise. They facilitate the administration of the game and provide guidelines for the post-game review. Moreover, good learning objectives also serve as criteria for evaluating both student performance and the overall adequacy of the exercise, pointing to fairly specific ways in which both can be improved.

Insofar as possible, student or participant-centered objectives seem desirable. These objectives will describe what the student is to learn, not the scope of the phenomena being simulated nor what the simulation looks like. An objective will tend to be more meaningful if it provides an answer to the question: What am I to know, understand, appreciate, or be able to do as a result of having participated in this exercise? To describe the content of what the student is to learn as specifically as possible, multiple objectives probably will be required for most instructional games.

In addition to indicating what is to be learned, i.e., the content, an objective should indicate the type of learning (cognitive or noncognitive) and the level of competence that is expected. With respect to cognitive learning, any of three levels of competence may be sought: (1) general familiarity with a subject, (2) understanding or knowing specific substantive facts or principles, or (3) the ability to apply certain knowledge or to perform a specific task, e.g., be able to use trade-off curves or set up a linear programming problem. The second type of learning, noncognitive, relates to conceptions of or attitudes toward something. A learning objective of this variety indicates that the simulation is intended to help the student acquire an appreciation of a problem or problem area, e.g., the role pressures of a political decision-maker, the complexity of an issue, or an adversary's perspective on a conflict.

This is only one of many ways of defining learning objectives. The most important thing is that they be defined and explicitly articulated. The discipline they impose upon both the designer and user of instructional games is likely to have its payoffs in student learning.

9 I am indebted to Dr. Robert C. Andringa for many of the arguments contained within this section.
SUMMARY AND CONCLUSIONS

A number of problems in the structure and use of educational simulation have been identified and reviewed. I have suggested that credibility rather than validity is the prime requisite for an effective instructional simulation. Credibility, however, must not be sought at the expense of symmetry in the structure of a game. Asymmetry can diffuse the learning experience to the point that much of the instructional value of the game is lost. The inadvertent introduction of multiple time frames also can dilute the value of a game. It can lead to a severe asynchronization of activities, which detracts from the credibility of the exercise and tends to breed frustration.

Perhaps above all else, a game must be manageable from the student's point of view. Unnecessary busy work and cumbersome activities should be designed out. Ease of administration is also an imperative. The more difficult a simulation is to administer, the greater the probability of distracting, if not devastating, administrative errors and lapses of control.

For the sake of both credibility and manageability, more continuous decisional and feedback processes seem desirable. The artificiality of point decisions and point feedback can give rise to the simultaneous problems of an informational void and decisional overload. As a result, many decisions may be more artifacts of flaws in the structure of the game than the products of processes analogous to referent processes.

Moving from problems that are essentially structural in nature to those that arise more from the way simulations are introduced and used, a number of potential pitfalls were identified and suggestions made for avoiding them. In introducing a simulation exercise, it was suggested that care be taken to foster realistic expectations regarding the results it is likely to produce. These results are not likely to be dramatic and oversell invites dissatisfaction. Similarly, in entertaining the use of a simulation exercise, care must be taken not to underestimate the time and material costs it is likely to involve. The value of a game may be lost, if one is ill-prepared to conduct it.

It was further argued that a simulation exercise should not be viewed in isolation from the student's larger educational experience. Ideally, the objectives defined for an instructional simulation should mesh with and reinforce those defined for other modes of instruction. It also was suggested that the student be cautioned not to mistake hypothesis for fact and that he be made aware of the tentativeness of many of the lessons that a game may convey.
Finally, it was suggested that the user of instructional simulation is obliged to provide guidance to student-participants in the form of clear learning objectives. Insofar as possible, these objectives should be student-centered and identify both the kind and level of learning that is sought.

The problems I have discussed pose a heavy burden for the designer and user of educational simulations. Although these demands may appear large in comparison to other modes of instruction, I suspect it is a misleading comparison. The burdens are perhaps clearer but probably no more onerous.

In concluding, at least four general implications seem to emerge from my analysis of problems in the structure and use of instructional simulation. First, the early hope of general purpose simulations that could adequately serve the purposes of education, substantive research on referent processes, and policy analysis was perhaps overly optimistic. While a number of games exist that have been used for all of these purposes, it is becoming increasingly clear that the best instructional simulations are those specifically designed for that purpose. Second and similarly, the prospects for general participant educational simulations designed to provide a valuable learning experience for participants regardless of their level of competence in a field appears limited. Once again, there are exercises that allegedly do this, allowing more sophisticated participants to find ever more subtle lessons in the game. However, considerations of credibility and manageability, to say nothing of content and associated learning objectives, suggest the need for simulations targeted at different levels of student competence. Third, despite the glamour and snob appeal of more complex and comprehensive games, small scale simulations of limited scope seem likely to play a more prominent role in the future. Fourth and finally, insofar as large-scale simulations are required to meet certain learning objectives, the use of the computer to reduce the burdens of participation and administration is likely to be found essential. The increasing availability and convenience of relatively economical time-share facilities bodes well in this regard.

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