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Simulation may be defined as (1) a technique of modeling (physically, iconically, verbally, or mathematically) some aspects of a real or proposed system, process, or environment or (2) the model (physical, iconic, verbal, or mathematical) of some aspects of a real or proposed system, process, or environment. Simulation may be used to generate information (research); generate new objects, processes, or systems (development); or develop knowledge of skills (instruction). When used for instruction, simulation represents certain elements of real life minus task-irrelevant elements. Given the types of representation of the stimulus situation, the response, and the feedback, classification of "simulations" or "simulators" is possible. Simulation may be used to present information (referential simulation), elicit responses (contextual response simulation), or assess performance (criterion simulation). Four features characterize contextual response simulation: (1) enacted or lifelike responses are made to (2) nonreal stimulus situations that (3) provide feedback to the student vis-a-vis his behavior in the on-going context that (4) offers control. Transfer and motivation are additional factors to be considered. From simulations it is possible to learn winning strategies, principles and relationships, decision-making skills, identifications, procedural sequences, and skilled perceptual-motor acts. (A 104-item bibliography is appended.) (Author/SG)

Simulation: An Overview

Paul A. Twelker

It has become commonplace to open a discussion of simulation with phrases such as, "Simulation means many things to many people" or "Simulation is a popular but slippery notion that may be traced back to the beginning of time." However trite, these phrases accurately depict the situation. Simulation, in its various and sundry forms, seems to have become established in many scientific endeavors, from operations research to military training. The current popularity of the term "simulation" may be attributed in part to mass media, especially commercial television, which provides its home viewers with on-the-spot reports of the launching of space rockets, complete with simulated demonstrations of various phases of the astronauts' journey. Also, in the past couple of years, advertisers have been asked to tell the public when a demonstration of a particular product is "simulated".

It is interesting that the term "simulated" carries somewhat different connotations in each of these instances. In the first example, the meaning of the term closely parallels the dictionary definition - the assumption of the appearance of something without having its reality (Webster, 1966). For example, light produced from an electric lamp may be termed simulated sunlight. Thomas and Deemer (1957) paraphrase Webster in the following way: "To simulate is to obtain the essence of, without the reality". An astronauts' coupling of two space vehicles may be termed a simulated demonstration since it is difficult to film in space for television presentation, and so it is accomplished in the laboratory. Yet, the demonstration clearly shows the essence of what is thought to happen in real life.

On the other hand, the second example of the use of "simulated" in television demonstrations often parallels another popular usage of the term that refers to the assumption of superficial resemblances, often for the sake of deception. This usage has been adopted in the biological sciences, where simulation is defined in <u>A Dictionary of Scientific Terms</u> as the "assumption of features or structures intended to deceive enemies, as forms of leaf and stick insects, and all varieties of protective coloration". Many simulated demonstrations and television commercials might better be termed "exaggerated" demonstrations, and this author sometime wonders if the word "deceptive" might even be more descriptive than "exaggerated". Nevertheless, the simulated demonstration does show the essence of what <u>might</u> happen in real life. The only problem from a consumer's point of view is to determine the authenticity of the demonstration in terms of the probability of its happening under all but the most ideal conditions in real life.

Purpose

The purpose of this paper is to define simulation and indicate the boundaries of simulation. Once this is done, some crucial assumptions that underlie the use of the technique for instructional purposes will be discussed. Finally, some of the reasons and rationale for using simulation will be presented.

A Word About Definitions

Basically, every definition of simulation takes the form of,"Simulation is an _______ of (a)_______." Two types of words or phrases are used in the first blank:..words that connote a process and words that connote a product. In the first instance, simulation involves the individual in actually doing an activity, such as constructing, operating, manipulating, or representing. In the second instance, simulation involves a more or less tangible product such as a game or a model. The distinction essentially is between simulation as an act and simulation as an entity. In the first instance, the means or techniques involved in simulation are inherent and important in its meaning, while in the second instance the end product of simulation is emphasized. This is pointed out in one dictionary's definition of the noun, simulation, as: (1) the act of giving a false impression, and (2) false resemblance. The distinction is also illustrated by a boy operating a model boat in contrast to the model itself.

Several types of phrases are used to complete the definition. Essentially, they either connote an object, an action, or a system. Words such as "game", "model", "features", "structures", and "reality" are commonplace. What this word is depends on large part on the subject matter or discipline in which the simulation is used.

Several examples should suffice to show the broad meanings attached to simulation. In social science, simulation may be either the constructing and manipulating of an operating model, or it may be a representation of reality (c.f., Guetzkow, 1962). For other social scientists, simulation is the study of structures in a laboratory (Zelditch and Evan, 1965). In education, simulation may mean the creating of games (Cruickshank, 1966) or a model of a system (Beaird and Standish, 1964; Cogswell, 1965). Or it may refer to a decision-making exercise structured around a model of a business operation (Greenlaw, Harron, and Rawdon, 1962). In biology, simulation is defined as an assumption of features intended to deceive (Dawson, 1962). For the behavioral sciences, simulation is a technique of substituting a synthetic environment for a real one (Kennedy, et al, 1960). Note that in this last definition, the writer leaves no doubt that an act or technique is involved in contrast to a simple product. In other cases, we cannot be sure what the author means without examining in detail what is simulated, how it is simulated, and for what purposes.

Harman, (1961), in his review of some definitions of simulation, states that all of the definitions have in common the characteristic of substituting other elements for some or all of the real elements of the system. He suggests that "perhaps the simplest and most direct definition of simulation is merely the act of representing some aspect of the real world by numbers or symbols that can be easily manipulated in order to facilitate study". McCormick (1964) gives a similar definition, but perhaps a little broader: "Simulation consists of some type of reproduction or representation of an actual or conceptual physical object, system, process, or situation, or of a theoretical construct." Note again that these two definitions point up the two ways in which the word is used. For Harman, simulation is an act of representing, while for McCormick, simulation may be either an act of representing or a representation, depending on the interpretation given. It should also be emphasized that the fact that one person thinks of simulation as a device, while another person thinks of simulation as a technique for setting up the device, is not undesireable. It simply points up the two accepted meanings of the word.

In summary, simulation may be thought of in general terms as: (1) a technique of modeling (physically, iconically, verbally, or mathematically) some aspects of a real or proposed system, process, or environment, or (2) the model (physical, iconic, verbal, or mathematical) of some aspects of a real or proposed system, process, or environment. The usage which might be adopted by an individual would depend largely upon his discipline, and the use to which the simulation is put.

Some Uses of Simulation

To illustrate the general definition of simulation, let us examine briefly three uses of simulation: (1) the generation of information about an operational or proposed system, processes, or environment (research); (2) the generation of new systems, process, or components (development); and (3) the development of knowledge or skills (instruction). The common characteristic, whether the scientist's main objective is to analyze a system, develop a new system, or communicate information about a system, is that the essence of the real life situation is obtained, but without all of the particular reality.

Generation of Information (Research)

Scientists are constantly asking questions and seeking answers. Simulation furnishes a powerful vehicle for the analysis of systems, things, or processes that may be too complex or too large or too fragile to observe in real life. When scientists analyze a system or component, knowledge is a product. This knowledge may be used to design and develop new systems, and in this sense, the distinction between research and development is simply a matter of degree. Frequently, applications of simulation for research are but a first phase of an activity whose eventual goal is the design and development of a new system or component, not simply the provision of general principles or data. It goes without saying that aspects of this newly generated information may be communicated directly to individuals through the use of simulation.

The use of simulation for research may be thought of in two ways. First, simulation may be involved in the conventional psychological experiment. For example, the experimenter informs a subject of the behavior that is expected of him and then presents the subject with pre-designed stimulus events, such as a pictorial lesson or a verbal lesson, each dealing with "mechanical advantage" and "first class levers" (cf., Gagne and Gropper, 1965). Several dependent measures are taken following the original learning of either the pictorial or verbal material. An examination of the materials used shows that the pictorial demonstration illustrates the concepts of mechanical advantage and simulates events in the real-life (operational) situation; in the same manner, he demonstration where words were used describes what occurs in real life. Again, reality is simulated. Both demonstrations obtain the essence of the operational situation, without the reality, and in this sense, involve simulation. It should be pointed out that the events that occur during a typical psychological experiment are atypical of events in real life. In real life, an individual's response in a situation is followed by events (feedback) from other components in the situation. McCormick (1964) illustrates this superbly: in real life, if a driver of a car veers over the center line, this may bring about interactions with other drivers. In a typical psychological experiment, this type of interaction doesn't exist, to say the least. The stimulus events are discrete events, taken out of context, with little or no reference to the system as a whole from which they are drawn. When simulation is thought of in these terms, the meaning of simulation emphasizes a representation or a model rather than the activity of constructing the model.

There is a second way in which simulation for research may be thought of. It involves what is called "systems research", which typically provides a greater degree of interaction than with the controlled laboratory experiments. Systems research that uses simulation represents the operational situation within the laboratory while at the same time providing control over the situation that is the forte of conventional psychological experimentation. Harman (1961) points out some specific advantages of simulation as a research technique: (1) it can compress or expand real time (for example, a school system operation extending over several years may be simulated in minutes with a computer to study long-term trends); (2) it provides the ability to experiment, test, and evaluate new systems for proposed changes in advance of having to make firm commitments; (3) it makes for more economical experimentation, both in terms of time and money; (4) it permits the replication of experiments under different conditions. When simulation is used in these terms, note that it may refer either to an act or an entity. Simulation may refer to the activity of constructing a model as well as to the model itself.

Literally hundreds of examples may be culled from the literature to illustrate the research application of simulation. School systems have been analyzed (Cogswell, 1965, 1966); the decision-making behavior of businesses has been examined (Bushin, 1964); and the dynamics of group behavior have been investigated using simulation (Briggs and Johnston, 1965; 1966; 1967; Briggs and Naylor, 1964). Other applications have involved research areas such as the study of the interaction of human behavior with computers and information processing systems, (Kennedy, 1962), driver research (Halbert, 1963), perceptual development, (Gyr, et al, 1962; 1966a; 1966b;), international relations (Guetzkow, 1963), cognitive processes (Green, 1964), and aircraft performance (Floddy and Paul, 1958). In each application, the simulation was a research tool or vehicle used to generate information about an object, process, or system. The simulation was a means to an end, not the end itself. However, in most instances, the term simulation still carries the connotation of the dual meaning -- simulation is a technique of modeling, but it may also refer to the model itself.

Generation of New Objects, Processes, or Systems (Development)

As noted above, simulation furnishes a powerful vehicle for the analysis of systems. Often, this information may be used to design or develop new systems or processes. When an individual wishes to design a new system, it is often difficult to "think on paper" -- that is, to attempt to determine all of the potential problems and occasions for decision-making at the abstract level. When this situation arises, the representation of reality via simulation offers the designer a powerful technique for developing the system, trying it out, and revising it, all within the confines of a laboratory. An excellent example of this use is the simulation of a hydroelectric installation. In dam construction it has become almost mandatory to first build a scale model of the installation to determine construction problems and possible solutions before the actual dam is built. Although the simulated dam is expensive to build and operate, its cost is but a fraction of the money saved by such procedures. Bushnell (1963) summarizes this use of simulation nicely: "When the design of new systems or the introduction of innovations into ongoing systems is in question, simulation can be used to manipulate variables to determine in advance the effect of changes. New systems can be tested or evaluated in advance of having to make firm commitments. Information about unpredictable effects that could be costly if they occurred in the real situation are also yielded."

To further illustrate the developmental use of simulation, consider the work of the Rand Corporation on game-simulation and long-range logistic planning for the United States Air Force (Rauner, et al, 1961). These efforts were designed to minimize the difficulties in making the transition from paper plans to full-scale operational situations. The authors used "game-simulation" to describe a technique that incorporated both the exploratory, unstructured characteristics of business or war games and the more rigid, controlled qualities of traditional computer simulations. Their experiments involved human decision-makers interacting with a simulated environment, represented partially by other humans and partially by computer programs that simulated the real world environment. The results of these exercises were expressed in terms of cost-effectiveness measures of various alternatives, as qualitative judgment about the feasibility or desirability of one organizational form or another, as decision rules, as information flows, and so forth. These results were tangible representations of future plans and helped planners by portraying activities and results at a level of detail necessary to make paper plans operational.

In summary, simulation allows the individual to try out the prototype system in his effort to determine potential problems, special design features, and even occasions for decision-making that he should know about before final implementation. The end goal is a product, not simply information.

Development of Knowledge or Skills (instruction)

The third use of simulation is as a training or instructional medium. To elaborate, simulation may be used in an instructional setting to: 1) present information; 2) elicit responses or exercise the student; and 3) assess performance. When simulation is used to present information, its meaning most closely parallels that of an entity -- perhaps a motion picture, a model, or a mock-up. The simulated object or event may be used as a concrete referent so that labels may be attached to exemplars (cf., Wallen, 1966). Not only may information be presented for the purpose of actual training or instruction, simulation may be used to indoctrinate individuals or to exhibit the feasibility of complex systems (cf., Harman, 1961). Here, the demonstration role of simulation is apparent. Also, simulation in a demonstration role may be used to simply develop enthusiasm among individuals for a particular activity or for a proposed change. Note that this differs from presenting information and desiring students to learn this information. If employees of a business firm expressed hostilities toward proposed changes, simulation might be used to exhibit the revised operation to reassure them or to present their new duties which might have to be learned (cf., Morgenthaler, 1961).

Simulation may also be used to elicit responses that are required in real life. An example is found in the unique application of simulation in teacher education as developed at Teaching Research (Kersh, 1961; 1963a; 1963b). Classroom simulation, in its prototype form, creates for the student teacher many of the relevant features of a single classroom situation called "Mr. Land's Sixth Grade". Mr. Land is the hypothetical supervising teacher with whom the student teachers work during this simulated experience. A complete cumulative record file is available on each child in addition to printed descriptions of the hypothetical school and community. The technique of filming the youngsters in the simulated class so that they appear to be reacting to the student teacher during the sequences is employed in sixty different problem sequences on sound, motion-picture film. In each case, the student teacher is expected to react to the film as though he were in a real classroom. Classroom simulation is based on the supposition that exposition of educational methods or principles could be expected to help the teacher talk about teaching, but only classroom experience (simulated or real) could train the beginning teacher to teach. It has been suggested that classroom simulation in this form helps students practice the discriminating of cues that signal potential problems that require immediate attention, make decisions in simulated conditions without fear of censure or embarrassment, and to modify their behavior on the basis of this feedback. (Twelker, 1967).

Another example of this use of simulation is the familiar academic game where real-life situations are simulated in a competitive activity. In the well known family entertainment game of Monopoly, players compete with each other for properties and the eventual wealth that comes from owning hotels on strategically located places. An example of an extension of this game to an academic business game is the American Management Association management-decision course.

A third aspect of instruction where simulation is of use is in the assessment and evaluation of performance. The assessment of performance may be carried out with simulation in all sorts of activities, and offers a unique opportunity to assess performance in a life-like setting that is often times untestable by other means. For example, it is difficult to think of a paper-and-pencil test as being adequate to test the performance of astronauts in a space vehicle coupling activity.

Schalock and his colleagues (Schalock, et al, 1964; Beaird, 1967) have shown that as test stimuli become more representative of the behavior to be predicted, and as the opportunity for response approaches the freedom characteristic of life situations, the power of prediction increases. Beaird points out that "the extent to which prediction was possible with the more life-like test is essentially unprecedented in the educational and psychological literature." He goes on to state that at least 50 per cent of the variance in the criterion that was being predicted to was accounted for in each of fifteen separate criterion measures that represent a concrete teacher behavior in the classroom and as much as 75 per cent of the variance was accounted for in some instances. The question of simulation for performance evaluation is discussed further by Gagne (1954; 1965), and Frederiksen (1962), Thorndike (1947), and Gibson (1947).

Again note that the use of the term simulation in this context primarily refers to the tangible model or representation of reality rather than an act of representing. In the work of Schalock's, films were used to simulate a complex teaching environment. The films obtain "the essence of, without the reality".

Toward a Definition of Instructional Simulation

In the remainder of this paper, our consideration of simulation will be limited to that which is primarily used for instruction. It is this use which is of primary interest to educators and instructors.

How does one go about defining "instructional simulation"? Are techniques such as role playing, sociodrama, psychodrama and case studies properly thought of as instructional simulation? What about moot courts, learning games, practice teaching and instructional motion pictures? It is clear that each technique includes elements of non-reality. There are a number of approaches that we may use in setting limits around what we mean by the term simulation.

The "Classification" Approach

Here we simply list every "simulation" we can find, and then deduce a series of limitations or constraints from these examples. Unfortunately, this approach will advance technology very little. We could hardly assume that a given "simulation" expert could even agree with another expert on such a classification. Further, such an approach will not lead us to exact limits. It will only lead to statements such as, "If your technique appears like any of these, it is a simulation". The end result will be a limitation as broadly defined as the list of simulations that are included. A more sophisticated classification approach might be to identify simulations on the basis of the type of response involved, e.g., drawing, loading, writing, assembling, directing, supervising, and so forth. Hopefully, this approach would lead one to specifying which responses are appropriate for simulation and which responses are not. It would be presumed that this in turn would lead to the drawing of limits around what is meant by simulation. For example, "Simulation is a technique that involves such-and-such responses." Unfortunately, the classification of responses depends upon an initial classification task of deciding what simulations are to be looked at in the first place. This leads us directly back to the problem discussed above. If it were not for this unfortunate concomitant of this approach, it might possess some merit.

The "Head in the Sand" Approach

Repeated failures at making some sense out of simulation as an area of study often leads to an approach that is characterized by the ostrich with its head in the sand. "If you don't ask me why <u>my</u> device or technique is a simulation, I won't ask you why <u>yours</u> is." This approach states that it's not important that a technique be considered in the generic sense as a simulation. Rather, it is a simulation by edict since it resembles another technique previously called a simulation. Or perhaps, it is a simulation because the word is in vogue and seems appropriate. This approach is not entirely without merit if one thinks that the time spent in the mental exercise of drawing limits around simulation might be more profitably spent in designing new simulations. "Stop theorizing and get to work" would be the battlecry of the proponents of this approach.

In some ways, this approach has merit. If the label, "classroom simulation", for example, seems to communicate to other people, why worry about such things as the meaning of simulation in general?

The "Death of Simulation" Approach

After reading reams of reports and supposed definitions of simulation, one might very well advocate that we stop using the word altogether to refer to a particular class of devices or techniques. This approach, in other words, denies that simulation as a noun carries any useful meaning since any definition will inevitably be vague and misleading. Such a drastic move is not unwarrented. Consider, for example, an individual who attempts to define simulation. He compares simulation "X" with a motion-picture training film and ends up with a statement of "no significant difference". He then turns to learning game "Y" and compares it with Monopoly, and he arrives at the same conclusion. Finally, in desperation, he compares another so-called simulation with sociodrama. Still, he cannot distinguish between the two since all of the techniques involve elements of non-reality. The logical conclusion he reaches is that all that takes place in instruction, short of using real life conditions, is simulation. Since this is somehow unacceptable, he concludes that simulation as a generic term is useless, and suggests that it not be used at all.

An alternate version of this approach suggests that simulation as a descriptor of a specific thing be discarded, but simulation as a verb be retained since it probably has a useful meaning. The outcome of this approach is to say that such-and-such a procedure uses simulation -- that is, "the obtaining of the essence of, without the reality", for example. Again, the result is still the same as before -- under the umbrella of simulation (this time as a verb), every conceivable instructional device or technique would fit. It is clear that in the generic sense, motion pictures should not be called a simulation since the connotation here is potentially ambiguous and useless.

The "Let's Try Harder" Approach

This writer believes that it is possible to define "instructional simulation" in terms that are meaningful and useful, and without resorting to the three approaches mentioned above. The advantage of baving such a definition is obvious. The task of developing simulations would be far easier if general guidelines could be specified for designing a class of techniques called "instructional simulations". Otherwise, each new simulation must be designed "from scratch" since no guidelines could be determined that would hold for such a class of techniques or devices. The danger of the "Let's start from scratch" approach is that it may lead to the inefficient use of time and money, and may result in a shortcut method of design where existing simulations are duplicated. Under these conditions, the designer proudly displays his technique as the offshoot of the famous "XYZ Simulation". This is unfortunate because the designing of a simulation solely on the basis of revision or duplicating of another simulation technique hoping that a "fit" exists, usually leads to a less-than-adequate instructional system.

The "Essence" of Simulation for Instruction

Recall that simulation may be thought of both in terms of a technique of modeling as well as the model itself. When simulation is used for instruction, the emphasis is primarily on the latter connotation. The unique advantage of simulation is summed up in the Thomas and Deemer (1957) definition of simulation: "to simulate is to obtain the essence of, without the reality". Harman (1961) points out that substitution of "essence" for "appearance" which is in the dictionary definition is a vital distinction. Simulation contains the important parts of, but not all of, reality. Simulations do not have to look like the real-life counterpart, but they do have to "act" like the real thing.

What does it mean to obtain "the important parts of"? First, it is clear that when a simulation includes important aspects of reality, it omits other elements of the real-life situation. When simulations are designed, unimportant elements from real life are subtracted. In the case of simulated displays, there is a reduction of information from the real-life source -- information that is in some sense unnecessary for the learning of the task. We might think of simulation in the following terms:

Simulation = (Real-life) - (Task-irrelevant elements)

where real life, in an instructional sense, is composed of task-relevant as well as task-irrelevant elements.

A simulation not only omits certain elements of real life, but it represents some of the elements that are included. In one sense, a simulation is a caricature in that some of the attributes of real life are not realistically represented. This representation may appear as a distortion or magnification or exaggeration. For example, a simulation of the atomic structure of a DNA helix may represent (distort) size. That is, the simulation is built to a scale, say, two centimeters to one Angstrom unit, so that a group of students may see the simulation without the aid of magnification. On the other hand, the representation may reflect more the characteristics of substitution or addition. The model of a DNA helix may use links of plastic to represent iconic bonds. In real life, these bonds are invisible, and are certainly not composed of plastic. In this sense, the represented link is a caricature of a real bond. With this in mind, we may think of simulation in these terms:

Simulation = (Real-life elements) + (represented elements of real life)

It is clear that a simulation designer not only has a task of choosing what elements of real life to include and what elements to omit, but he also has a choice of deciding how task-relevant elements are to be represented. In the literature, these considerations usually fall under the general topic, fidelity of simulation or precision of representation.

Omission of Task-Irrelevant Elements

By task-irrelevant elements we mean those elements that are not essential for the learning of the particular task. Note that these elements must not be irrelevant for the conduct of the task in real life -- if this were the case, simulation would be useless for instruction. The determination of which elements are task-irrelevant and which are task-relevant is closely tied to the instructional objective. For example, if the desired behavior were "List the principles involved in managing a class", many elements in real life would be "excess baggage" as compared with an objective such as, "manage the class". There is little need for an instructional system that includes the students (simulated or real) and information about the students with the first objective. Learning could proceed nicely with verbal descriptions of the principles. In the other objective (i.e., manage the class), the student must transfer what is learned to an actual behavior that requires some practice in performing it. If the system were novel, it is doubtful that merely presenting a learning situation where recalling the principles that may be applicable would enable the learner to perform the activity. Note that the transfer we are considering is from the instructional experience to real life. Transfer is a crucial aspect of simulation and will be reserved for consideration later in this paper.

Other factors are important in the determination of what elements are irrelevant to the learning of the task and hence subject to omission. For one, omission of elements may provide control in the instructional situation when one or more elements in real life would produce unpredictable occurances that may be dangerous to the learner. For example, if the desired terminal behavior is, "Pick up a rattlesnake and milk its venom", the instructional situation would be highly dangerous to the naive learner. Simulation might be used to bridge the gap from a "textbook" milking (i.e., looking at pictures or a diagram of the milking) to the real-life behavior itself (i.e., performing the milking). At one extreme a live rattlesnake, but with the venom removed (omitted) might be used. At the other extreme a dead snake might be used. In this case, the real-life element of life itself has been omitted, together with other features such as the ability to bite and so forth.

Another factor that is important in the task of labeling irrevelant elements is stage of training. In the preceding example, a live rattlesnake (where no elements of real life are omitted) might be appropriate for latter stages of training while a rubber snake (where many elements are omitted) would be more appropriate earlier in instruction.

The success that a simulation designer has in determining the task-relevant elements will determine to a large extent the success of the simulation in meeting the objectives of instruction. The designer faces three outcomes of his efforts:

1) task-relevant elements as well as some task-irrelevant elements are included;
2) some task-relevant elements are omitted and some task-irrelevant elements are included,
3) task-relevant elements are included and task-irrelevant elements are omitted.

In the first instance, it is possible that the closer simulation approaches real life unnecessarily, the more costly it will become. Further training effectiveness may suffer since the trainee is forced to consider irrelevant elements. It is a well established fact that when too much information is presented to the learner, that is, when the learner is overloaded or in human engineering terms, when signal input rate exceeds operator information-processing capacity, signals are not only unidentified but they function as a distraction. The psychological literature abounds with instances where too much information may cause confusion and a detriment to transfer performance. Yet, the question of just how much information to omit is largely unanswered. Travers' work (1966) has only touched the surface of the whole matter of visual and auditory compression.

In the second instance, the designer clearly "misses the boat" if he includes the wrong (task-irrelevant) elements and excludes the right (task-relevant) elements. It would be a wonder if much would be learned in this circumstance.

The situation represented by the third case is one where the simulation has a chance of being effective. It will possess all of the elements that are necessary for the trainee to learn, and will exclude all that is irrelevant for his learning of the task. Also, it might even be the most economical, in terms of the three outcomes mentioned, since irrelevant features are excluded. Here again, the matter of the appropriateness of including some task irrelevant elements to enhance <u>transfer</u> especially in later stages of training, is important to consider. Research by Twelker (1964a; 1964b) and others have shown that instructional conditions optimal for learning certain objectives may not at all be suitable for other objectives, e.g., transfer.

Representation of Task-relevant Elements

Once the task-relevant elements have been identified, the simulation designer must decide how best to represent those elements. For present purposes, it seems appropriate to consider four categories of elements that may be represented: 1) stimulus situation; 2) response; 3) feedback; and 4) context. It is clear that if any element of any of these four categories is represented, the result is a simulation in the general sense of the word -- the essence is obtained without the reality. Presently, we shall examine simulation from a more restricted point of view, and draw limits around what we mean by "instructional simulation".

Types of Stimulus Situation Representation

By stimulus situation is meant the cues that are presented to the learner that serve to elicit a response. In the most simple terms the stimulus may be a combination of letters that stand for two phonemes in a paired-associate task. In the case of gunnery practice, the stimulus is a target. In psychological terms the stimulus that is represented is an external stimulus, defined as an energy change in the environment that produces a response, as compared with an internal stimulus that originates from within the organism (e.g., hunger pangs).

Unfortunately, there exists no simple way of classifying stimuli that is known to this writer. Further, an attempt to develop a taxonomy on purely physical criteria (e.g., is it a picture of a symbol?) will end in failure since communicator intent must be considered. For example, a model of Uncle Sam might be termed a concrete representation if it stands for a person. If the model, Uncle Sam, stood for a country, should it still be classified as a concrete representation. The categories mentioned below are better thought of as possible ways in which a stimulus might be presented, and do not necessarily represent mutually exclusive categories. A stimulus could be classified into more than one category.

The stimulus that is given to a learner might be a real-life stimulus, and, as such, nothing is stimulated. A real life stimulus that is presented to the learner may involve one or more senses: vision, hearing, touch, taste, or smell. Most often, only the audio and visual modes are used in instruction, and our discussion will be limited to these modes.

If the instructional designer does not wish to present real-life stimuli, he must then simulate real life. Real life may be simulated in a variety of ways. The stimulus may be a concrete representation. A model of an apple that possesses many of the attributes of an apple, such as shape, size, color, and texture, but is made of wax may be termed a concrete representation. It is clear that the concrete representation may very closely approximate the real-life apple. It may even use real seeds and a real stem. But in some way reality has been altered by omission and representation of elements.

There are degrees of concrete representation. At one extreme is a nearly perfect representation of an apple as noted above. At the other extreme may be a gross caricature of a real apple -- a red, hollow shell that emphasizes certain features for the sake of instruction. In this case it might be called a "mock-up" in media terms. The important thing to note is that concrete representation allows the learner to experience <u>directly</u> the phenomena. The learner may see, and some cases hear, touch, taste, and smell the simulation. Stimuli that may be classified as concrete representations are three-dimensional, thus allowing the learners to interact with the stimulus. Edling (1966) suggests that "all senses can be employed to provide cues to the learner" in the case of three-dimensional stimuli.

The stimulus may be an <u>iconic representation</u>. Iconic representation, as described by Bruner (1966) "depends upon visual or other sensory organization and upon the use of summarizing images"

> "Iconic representation is principally governed by principles of perceptual organization and by the economical transformations in perceptual organization that Attneave has described--techniques for filling in completing, extrapolating." (Bruner, 1966, p.11).

Iconic representation may deal with pictures -- with sense of vision. Edling (1966) notes that representation that are iconic are " 'objective' because elements in the representation (the picture or drawing) correspond to specific elements in the reality." The key in iconic representation is <u>correspondence</u>. The elements in the model (in the general sense of the word) "contain cues that make it possible for a learner to associate an object with visual representation of that object <u>without</u> prior association with the object itself" (Edling, 1966, p. 38).

Edling (1966, P. 39) presents a list of "objective" visual stimuli that is helpful in realizing the wide range of iconic representations.

Motion pictures, with illusions of 3-D in color
Motion pictures, with illusion of 3-D minus color
Motion pictures, 2-D, in color
Motion pictures, 2-D, minus color
Still pictures with illusion of 3-D, in color
Still pictures, with illusion of 3-D, minus color
Still pictures, two dimensional in color
Still pictures, two dimensional, minus color
Painting (realistic), in color
Photograph of painting (realistic) minus color
Sketch (with shading)
Representational color cartoon (with animation)
Representational color cartoon (without animation)
Representational cartoon (minus color)

Note that as the iconic representation moves from the motion picture to the still photograph and to the cartoon, the number of cues that are available to the learner decrease.

Visual stimuli are not the only stimuli that may be iconically represented. Sounds may also be classified as iconic since they depend on perceptual organization. Sounds are "objective" in that elements in the representation (the recording of a bullfrog, for example) corresponds to specific elements in real life. Here again, there are degrees of representativeness. A stereophonic recording of the mating call of the bullfrog has more cues that correspond to reality than a recorded sound effect that sounds like a bullfrog but is produced by other means, for example.

So far, we have considered the representation of stimuli by concrete and iconic means. A third type of stimulus representation is analogue representation. By that, we mean most simply that the property of correspondence changes to non-correspondence. One property is used to represent another. Whereas iconic representation model relevant properties of real life by those properties themselves, analogue representation models relevant properties of real life by other properties, so that a code or legend is required in order to learn. "This condition requires that a learner have associations with the visual stimulus and the object it represents if the visual stimuli is to be associated with the object" (Edling, 1966, p. 40). The learner must know the code or legend in order to associate the representation with real life. For example, the flow of electricity may be represented in analogue fashion using water flowing through a pipe. The well-known cartoon figure, Uncle Sam, is an analogue representation, since it stands for a country. In both instances, the learner must be told what the model stands for in order to learn. Examples of stimuli that are represented by analogue include:

Symbolic cartoons
Diagrams
Maps
Charts
Graphs

A final type of stimulus representation that shall be considered is symbolic representation. For example, numbers and words are symbolic models of real life. In one sense, it is a form of analogue representation in that the property of non-correspondence is still operative, and one property (e.g., a word Plato) is used to represent another property (the man, Plato). Yet, in terms of a continuum of realism, it seems that a large gap exists between maps and similar models, and symbolic representations, such as words. To this end, representation of reality by symbols is best thought of as a separate category.

Types of Response Representation

By response we mean an observable change in behavior, this change being an activity usually effected by muscles. In a scientific sense, all that is required of a response is that it be measurable by some means. From an instructional point of view, a recitation of a poem, an identification of a target on a radar screen, and the handling of a problem situation in a classroom, are all responses. For our purpose, it seems appropriate to think of five types of responses. The latter four are representative of (or simulate real life responses):

(1) real-life response to real-life stimuli;
(2) enacted response (doing the task in a non-real-life setting);
(3) iconic response (drawing what would be done in a non-real-life setting);
(4) analogue response (giving a non-corresponding response in a non-real-life setting);
(5) symbolic response (saying, writing, or choosing among given alternatives what would be done in non-real-life setting).

A real-life response must be made to a real-life stimulus. If the stimulus is simulated, then the response should be regarded as representative of real-life since it is not made to real-life stimulus, and transfer is involved from the instructional situation to reality. Confusion will arise if this point is not clear. The basis for labeling a response "enacted", "iconic", "analogue", or "symbolic" is not whether or not the real-life response involves doing, drawing, writing and so forth. The basis of labeling is whether or not the response is representative of real-life in the instructional context, and how real-life is represented. The real-life response may take any form, but we are not distinguishing these forms now. The above-mentioned labels of enacted, iconic, analogue, and symbolic only serve to identify the type of representation of the real-life response, whatever form it may take. In the simulation the learner may do the real-life activity (enactive response), draw the activity (iconic response), tell about it (symbolic response), or do something that is an analogue to the real-life behavior (analogue response). It makes little difference in this taxonomy what kind of real-life response it is that is represented.

With this in mind, let us examine each of the four types of response representations in greater detail. The enacted response is essentially doing what is done in real-life with the exception that it is elicited by a simulated stimulus situation. For example, in a learning game, a student may play the role of a Senator. He may make speeches. He may lobby, and attend conferences. But, this enactive behavior is elicited, not by the real-life legislature of that state, but by a series of rules and instructions for playing the game that simulates real life. The responses are enactive since he does what is usually done in real life. Enactive responses usually are characterized by an interaction with the stimulus, and are most realistic in terms of the four categories mentioned above. Enactive responses require the least interpretation by observers witnessing the behavior. Further, witnesses may mistake the response as real life if they fail to observe the stimulus. The iconic response is essentially drawing what would be done in real life. In designing an instructional simulation, this type of response would probably not be used to any great extent. Yet, it definitely represents a class of responses that should be recognized. Needless to say, this type of response might require more interpretation on the part of an observer who witnesses the behavior.

The analogue response is elicited by an analogue stimulus. Recall that non-correspondence is the property of analogue representation. One property is used to represent another. Similarly, one response is used to represent another in an analogue fashion. This requires that the learner must transfer from the analogue response in the instructional situation to a real-life response. Theoretically, this transfer would be more difficult than transfering from an enactive response to a real-life response.

An example of an analogue response would be the turning of a faucet to restrict water flow, when the water flow represented electrical current and the faucet represented a switch. In real-life, the response would be an up or down motion with a lever, while in the simulated situation, the response would probably be a turning motion with the hand. Note that in both instances, the response is not thought of separately from the stimulus, since, in psychological terms, a stimulus elicits some response. Again, as is the case with iconic responses, the use of analogue responses may be somewhat restricted because of the transfer problem. It should be noted, however, that rarely would analogue responses be used apart from symbolic or enactive responses, so the problem of transfer may be minimal. Symbolic responses may serve as verbal mediators in the real-life situation.

A fifth type of response representation that we will consider is the symbolic response. Saying what would be done in a given situation, writing what would be done, or choosing among the given alternatives, are all types of sumbolic responses. As is the case with symbolic stimuli, symbolic responses could be considered a form of analogue response. An example of a symbolic response in classroom simulation training, where problematic classroom episodes appear on a screen in front of the learner, and the learner is expected to respond to them, would involve the learner in telling what he would do in the problem situation. Essentially, the student would "armchair" the life-like response. If he chose to act out the response, it would be classified as an enactive response since he was doing what would be done in real-life except to a simulated stimulus. Conceivably, the student could even choose to draw his response in which case it would be termed as iconic response.

Types of Feedback Representation

We need not concern ourselves with types of feedback representation in detail since they parallel those of stimulus representation. In instructional situations, feedback is a stimulus following the learner's response, and may possess the various features discussed under stimulus representation.

Types of Contextual Variables

A dictionary definition of context refers to the whole situation of the background or environment that is relevant to the (instructional) situation. As such, it would be difficult to distinguish context from stimulus situation in many cases. This writer has chosen a narrower meaning for context. Context is learner-oriented. It refers to how the learner perceives the situation: Is it real or is it non-real? The learner brings to the instructional situation certain elements that are not necessarily apparent to a non-participant observer may not see the supervisor and may not be told that a student teacher is conducting the class, and think that what he observed was in fact actual, unsupervised teaching. Yet, to the student teacher, it may be far from the real thing if the supervisor, even though absent for a moment, may still exercise control and influence over the class. In some way, the context for the learner is different. It has been altered. The children (the stimuli) may be real life; teaching (the response) may be real life; the consequences of this behavior (the feedback) may be real life. But the fact that he is practicing under supervision changes the context. What is omitted in the practice teaching example, in terms of context, is the absence of direct control over the class. Of course, as the term progresses the student teacher is given progressively greater autonomy. Thus we see that one important contextual variable is the presence of a supervisor or evaluator of performance.

Another important contextual variable is the quantity and type of stress. In an instructional situation, the learner perceives of the situation in a different manner, and this may be related to the degree and type of stress in the situation. In an aircraft simulator, no amount of "bungling" will produce an actual crash. In a simulated classroom, errors in judgment do not produce actual chaos. In cross-cultural simulation training, saying the wrong thing to a village chief will not produce actual rebellion. The context is different from real life, and this difference may be expressed in terms of stress. In the instructional situation is relative safety, while in real life may be jeopardy; the learner perceives this. The contextual difference requires the learner to transfer to real life after instruction, and this transfer may be initially difficult. Examples are plentiful of individuals performing more than adequately in target practice, only to freeze or misfire when confronted with the real enemy and real bullets. Needless to say, it is up to the instructional simulation designer to maximize the probability of effective transfer.

In some cases, stress as a contextual variable may be rather effectively simulated. One example is a ninety-two step procedural skills trainer that trains an individual to activate a missle (Cox, et al, 1965). Confronting the trainee at all times is a panel with a red light that glows when a particular missle sub-system is over-heating and endangering the mission. The objective of the mission is for the trainee to ready the missle for firing without delaying that may cause over-heating of this particular sub-system. Even though the trainee perceives the situation as simulated, the introduction of this factor seems to be effective in simulating actual stress. Another example of stress produced under simulated conditions may be found in classroom simulation training (cf., Kersh, 1965; Twelker, 1967). Here, it is not uncommon for several students during the course of training to become quite frustrated when confronted with a problematic episode which they are unable to handle.

Other examples show individuals having an amazing capacity to "throw themselves into the situation". This phenomenon has been remarkably illustrated in a sequence shown by the popular television show, Candid Camera. The situation involved an individual delivering a key to a particular office. The individual was requested to sit in the waiting room and wait until the gentleman to whom the key belonged appeared. A television set in the waiting room was then turned on and the messenger observed what he thought was a "soap opera", but which in fact was a staged plot involving the key which he was attempting to deliver. Although the stimulus was presented by means of television, the individual still interacted with the drama as though it was real life.

Some Examples of Classification

Given the types of representation discussed above, it is quite easy to classify various devices and techniques that are called "simulations" or "simulators". For example, classroom simulation (Kersh, 1963a; 1965) uses an iconic stimulus situation mode, usually motion pictures, although still pictures have been used. The responses that are elicited are either enacted in front of a large, rear projection screen, or "arm-chaired" -- the learner explains how he would respond but without acting out the response. Feedback may be presented either by film, showing the probable class reactions to his behavior, or symbolically by telling him what might happen. The reader is left to assure himself that other instructional techniques may also be classified in the same manner.

Type of Representation

Device or Technique	Stimulus Situation	Response	Feedback
Classroom Simulation	Iconic Concrete	Enacted or Symbolic	Iconic or Symbolic
Link Trainer	Concrete	Enacted	Concrete
Carnegie Tech Management Game	Symbolic Concrete	Enacted or Symbolic	Symbolic
NAPOLI	Symbolic Concrete	Enacted	Symbolic Enacted

Figure 1. Classification of selected instructional "simulations" in terms of type of representation.

Three Types of Instructional Simulation

Now that the overall question of what types of elements in real life may be simulated (omitted and represented) has been answered, let us turn our attention to some constraints on the term, instructional simulation. Needless to say, we have set the stage for calling everything that takes place in instruction, simulation. After all, when one or more elements in the stimulus, response, feedback, or the context is omitted or represented, it may be said that the particular stimulus, response, feedback, or context is simulated. In fact, it has been shown that a given "simulation" may be classified in terms of what type of things are simulated in what way. It is clear that each of the above types of simulation fulfill the Thomas and Deemer definition of obtaining "the essence of, without the reality". Recall the three uses of simulation for instruction that were mentioned above: (1) presenting information; (2) eliciting responses; and (3) assessing performance.

For convenience, let us use the term "referential simulation" to describe instructional techniques that emphasize the use of simulation, in the general sense of the word, to present information or for demonstration. Star field projections, developed to a fine art by planetarium producers, are prime examples of simulators used for demonstrational or representational purposes. Planetariums can provide a simulation of the night sky, and other celestial phenomena, so realistically that it is often difficult to distinguish the simulated from the real. Much instruction could benefit from the wider use of concrete or iconic models that illustrate in a clearer way than words, concepts or principles that are being taught (cf., Bamford, 1955; Gropper, 1963; 1966).

For the second use, that of eliciting responses, or more correctly, providing opportunities for practice or exercise of previously learned principles, or for the trial-and-error learning of principles, let us adopt the term, "contextual response simulation". The appropriateness of this term becomes clear if we consider that the technique exercises the student or provides him with a <u>context</u> for <u>response</u> or practice. For the third use -- assessing performance, perhaps the term, "criterion simulation" best describes this application.

In the remainder of this chapter, the second type of simulation, contextual response simulation, will be discussed. Clearly what will be talked about will have application for the other two types of simulation. Yet, simulation, from an historical perspective, is best thought of in terms of contextual responses. Later chapters will discuss in depth, criterion simulation.

Contextual Response Simulation

Four features are characteristic of contextual response simulation:

(1) enacted or life-like responses are made to
(2) non-real life stimulus situations that
(3) provide feedback to the student vis-a-vis his behavior in the on-going instructional context that
(4) offers control

Let us examine each of these points in detail. Note that what is said has relevance to the consumer of simulations as well as to designer of simulations.

Enacted Responses

Enacted responses involve the learner in doing the task in a non-real-life setting. In contextual response simulation, the learner behaves as though he were in a real-life situation which demands the same behavior he is engaged in during the simulation exercise. The learner does not simply state what he would do under similar circumstances. Of course, the eliciting of "what I would do" behavior may be related to the objectives of instruction, but involves behavior that is incidental to real-life behavior. For example, the learner might engage in the evaluation of choices given to him, the problem being that real-life situations demanding decision making are not presented to the learner in multiple-choice test questions. Furthermore, as Frederikson (1962, p.332) points out, written situations do not permit the instructor to assess the style of behavior that may be exhibited in real life, the corollary being that the student does not have an opportunity to practice the real-life behavior in various styles to discover which is most appropriate for him.

Garvey (1967 p. 6-7) has stated that the simulation technique is based on role-playing, which is defined as "the practice or experience of being someone else" which "requires the student to perform a role which he is not accustomed to playing" for the purpose of understanding the situation of another person or of relationships or of actions. In one sense, the restricted meaning of the term role-playing is appropriate. In learning games, the learner behaves as though he were in a real-life situation, but adopts a role of a senator, for example, in a legislative assembly. Clearly the student is "being someone else." Yet, in another sense, this definition of role-playing is too limiting. In some simulations, the emphasis is not so much on the adopting of another person's role as it is the adopting of the learner's own subsequent role that he will perform in real life. This is clearly seen in skills training with aircraft simulators, where the learner practices skills in a life-like situation. The classroom simulation technique developed at Teaching Research (cf., Kersh, 1963; 1963b; Twelker, 1967) is an example of the emphasis on the transfer from the instructional situation to the real-life situation, where the role that is being practiced is the learner's own role. The difference between these two emphases may be summarized in the following manner: simulations that are based on the learner "being someone else" may be termed "role-assuming" simulations while techniques that are based on the learner practicing his own future role may be referred to as "role-performing" simulations. Of course, each type of simulation has in common the element of the learner behaving as though he were in a real-life situation.

Note that this conception of contextual response simulation is tied to use, and not necessarily to form. For example, an aircraft simulator may be thought of in terms of contextual response simulation because it is usually used for exercising the pilot in certain required skills. However, it could be considered a referential simulation if it is used simply to demonstrate a control function or to illustrate the placement of controls. In the same way, learning games may be thought of as a criterion response simulation. Yet, it may be a referential simulation for a particular student who observes the game in progress for the purpose of seeing an example of learner-controlled instruction. In a word, the distinction is between a learner as an observer (referential simulation) and a learner as a participant (contextual response simulation). Some have said that noise is not noise, unless it is heard. Similarily, a contextual response simulation is not a contextual response simulation unless participants are engaged in the learning activity. In a very real sense, then, what is being described is a technique, not a model. Instructional simulation is a way to use a model, not necessarily the model in and of itself. Contextual response simulation is more than a series of episodes, or a machine, or a scenario and rules of a game. It is a way of using these things in an instructional system that guarantees involvement of the learner in non-real-life stimulus situations that simulate some aspects of real life.

Museums, in cooperation with local school districts, are beginning to recognize the value in modifying the displays so that the student is a participant in the learning experience rather than simply an observer. For example, typical museum displays, such as a pioneer house, filled with all of the furniture tools and clothes of that period, are shown to students, many times behind a rope or even glass. The student has little opportunity to learn about how life really was in the pioneer days, except vicariously. The modified displays allow children to participate as a frontier man in a "life-in" museum perhaps for several days and live the life of a pioneer in this simulated situation. The student works with the tools of that day, "hunts" food, prepares the fire, chops wood, tends animals, reads books of that day, and wears the clothes that were worn, all within a realistic but controlled environment. Simulation allows the student to move past the barrier that limits his experience to observation, to an experience where participation is possible. In the words of Clark Abt, the learner "is forced to interact with the material in an active way rather than a passive way" (cited in Twelker, Crawford and Wallen, 1967).

Non-real-life Situations

The stimulus may be represented in many forms. It makes little difference as long as consideration is given to the fact that transfer is involved from the instructional situation to real life. Recall that a response is made to some object. The specification of a response includes both the object acted upon and the nature of the response. Performing the task in a non-real-life setting (an enacted response) may be done in the presence of a number of stimulus situations. For example, the response, "Manipulating controls" may be done with a cardboard mock-up placed in front of the student. If the student goes through the motions of operating the controls (pantomiming), he is enacting the response, but to an iconic (pictorial) display. On the other hand, manipulating controls as a response may be accomplished with a model of a real-life control panel. In this case, the student enacts the response to a stimulus display that might be termed "concrete" as compared with "iconic".

Historically, simulation designers have placed a lot of emphasis on the physical appearance of stimulus situations. Designers have often been overly concerned with the realism fidelity of the simulation as an important dimension and have designed simulations that resemble as closely as possible the real situation. This has led to the building of aircraft simulators that duplicate entire cockpits, for example, often for the training of basic skills of aircraft operation which have little or no need of the high fidelity provided.

Gagne (1962) and others have implied that the stimulus dimension is not the only important factor to consider in the design of a simulation. A designer does not start with physical appearance, whether it be a game or a training device. Rather, he concerns himself with the <u>response</u> dimension or what Gagne refers to as "operations" or "tasks" (parts of operations). Operations are defined as interactions between man and machine or between man and his environment. It should be understood that the environment may include other men, and we might specify that type of interaction as well, that is, between man and man. Once the simulation designer knows what operations he wishes to teach or exercise (and conversely, what operations or tasks he does not wish to teach or exercise), he then considers the appropriate means to bring this learning about, and this brings him to the question of how his simulation will look. He does not start with physical appearance, scenarios, or rules of the game in the hope that the operation is taught. Rather, he concerns himself with specifying the operations, and then specifying the conditions - the stimuli, feedback, and context, that will provide a realistic environment for the operations to take place that will bring about a change in the student. In other words, form follows function.

Feedback

The fact that an individual can interact with or participate in a stimulus situation, whether that be composed of man, machine, or a combination of both, suggests the third feature: the instructional technique can present feedback with respect to the learner's behavior in the ongoing instructional (simulation) context. In real life the individual interacts with another individual, for example, and receives feedback from the individual. Or, the individual interacts with a machine, and receives feedback from the machine, in the general sense of the word. The real-life situation is dynamic as compared with static. For every action, there is a reaction from the environment of one sort or another. This feature is provided for in contextual response simulation. For example, in a learning game, peers' reactions to an individual's decision are quick and at times far more effective than a teacher's mark in a gradebook. In fact, some have suggested that learners often may listen to peers more than teachers.

Control

Contextual response simulation provides the learner with an experience over which he or someone else has some degree of control. The real life situation is uncontrolled and subject to unpredictable variation, no matter how well supervised it is or how predictable it has been in the past.

Reproducability. An obvious characteristic of control is reproducability of the stimulus or instructional conditions. The instructional experience may include provision for the student to repeat the problem and respond in different ways, all the time receiving feedback as to the correctness of the response. For example, in classroom simulation training, students may try out different responses to the same stimulus situation and see probable classroom reaction to their responses by means of feedback films.

Planned Variation. The instructional experiences might also include planned variation of the simulation situation (cf., Gagne, 1965). This often serves to enhance later stages of training and is thought to be an absolute requirement for transfer. In this case, we do not wish to present the same stimulus situation time and time again. By doing so, we would risk a biased training of an individual by limiting his experience to a narrower range than normal. The result of this excessive type of control would be that it would contribute to the learning of the task in the instructional content but detract from the transfer required when the learner must exhibit his newly attained skills in real life under varying stimulus conditions. For example, in classroom simulation training, students are shown a limited number of behavior problems, and are asked to respond to these problems appropriately. If the student perceives the behavior problems as "only the way it happens" in the classroom, he is due for a rude awakening when real life problems actually occur under slightly different circumstances. Control, in terms of reproducability of the exact stimulus, would be useful in training under these conditions, but would produce a negative effect on transfer. Another example would be in the area of counselor training. What problems might be encountered if student counselors were trained with a technique that taught them to respond to a simulated client that behaved in a highly predictable fashion all of the time? The student would certainly be ill-equipped to confront his first real-life patient.

Not all types of simulation offer the same amount of control. Shubik (1960) distinguishes between "environment rich" and "environment poor" games, and points out that different games offer more control than others. The type of game used at RAND by Goldhamer and Speier "is relatively unstructured, (and) calls for considerable role playing and for discussion by both the referees and the players as to the validity of the moves" (Shubik, 1960, p. 737). Shubik cites the economic game developed by Siegel and Fouraker (1960) as much more closely controlled.

Cohen (1962) points out that a limitation of learning games to explore aspects of international relationships is the "very great difficulty of replication". He states that it is virtually impossible to replicate a game from day to day or from term to term or from university to university so that all of the many variables involved in the outcome of the game are held constant. Thus it is difficult for a student to play a game, and develop an hypothesis or theoretical proposition about the cause and consequences of policy, and then expect to test that proposition in a replay. Cohen suggests that probably the best that can be done is to use the same scenarios in different plays of the game and then compare the moves and outcomes, but not hope to draw theoretical conclusions about causes and consequences. This caution would also hold for the planned variation of particular conditions for purposes of experimentation.

Since the response is enacted (life-like) and the stimulus situation is not real-life thus offering control, there is little hazard or threat to the welfare of the individual. It has been pointed out that Classroom Simulation (Twelker, 1967) allows the student to react to filmed problems as though he were in a real classroom. The student is not subjected to embarrassment that may result from an inappropriate move on his part. Students are not subjected to inept instruction or management, or embarrassment for that matter from a student teacher who either requires further training or simply wishes to try out various strategies without fear of censure or negative consequences that affect others.

There is a more general consideration of the use of simulation as a substitute for real life. It may be summed in the words, "When learners can't learn about the workings of a legislative body by actually participating in such a body, then simulation is an ideal technique." If an individual can't design a city in real life to learn about some important factors in urban renewal, then use simulation. If it is too expensive to practice the conduct of a small business in real life, then build a computer simulation, and experience bankruptcy painlessly.

Allow me to summarize the features of contextual response simulation. Contextual response simulation involves enacted (life-like) responses in non-real life settings. These stimulus settings may represent a "simulation continuum" that ranges from very realistic situations to situations that are not at all realistic. Feedback is provided in the on-going instructional context. These features allow the student to participate in a controlled learning experience which presents little or no hazard to the individual. These characteristics of contextual response simulation are tied to use and not necessarily to form.

The Scope of Contextual Response Simulation

Now that the features of contextual response simulation have been discussed, it should be possible to examine the extent to which several instructional techniques meet the criteria adopted for this type of simulation. What about such techniques as moot courts, mock congresses, case studies, role-playing, socio-drama, academic games, and other related methods. Let us examine these techniques one at a time.

Moot courts and similar experiences. First, a moot court involves law students taking the part of attornies in order to "try" a case. Students have the experience of preparing depositions and briefs to prepare for the "day in court". Clearly, students are involved in performing various real-life tasks but in a non-real-life setting. Students who are involved in the moot court are clearly participants in the learning experience. They practice preparing briefs as though the case were real. They practice delivering the case in front of the judge and peers.

Robinson (1966) maintains that moot courts and related techniques cannot be considered as simulations because the techniques involve more role-playing than simulations. Further,

> "simulations tend to formalize and program various aspects of the systems that they represent; that is to say, they permit less flexibility than do the free-wheeling mass conventions. Simulations concentrate more on the processes by which decisions are taken and devote less attention to the institutionalized and particular procedures of conventions or congresses. They require the participant to engage

more in the dynamic interaction of the system and expect less of him in the way of second-guessing or of playing the role of a particular person or position." (1966, p. 95).

Robinson points to the de-emphasis of role-playing, the highlighting of process factors, and the formalizing of programs for the conduct of the simulation, as the main distinctions between simulation and techniques such as moot courts. For this writer, the first point seems questionable in view of the many games now being developed that involve the player in situations for which he has no background. However, the matter of control that the instructional conditions offer is inherent in the other points. Simulations are not entirely free-wheeling. They operate within bounds - bounds that involve the rules of the game and even the conduct of the game in "rounds". Moot courts are not characterized by control, and the supervision that is possible with such control. When students are preparing briefs, no provision is given to monitor the work. Neither is there any monitoring of student behavior for the purpose of providing feedback in the instructional context. In some ways, the moot courts are parallel techniques to practice teaching where control is minimal.

Psychodrama, socio-drama, and role-playing. At first glance, both psychodrama and socio-drama could be thought of as possessing the characteristics of a contextual response simulation. A closer look reveals that psychodrama is a method of diagnosis and treatment of personality problems, and when used for group therapy becomes socio-drama. Katona (1955) states that "in its original meaning, sociodrama apparently is some sort of social panacea, a means of cure for troubled groups, as psychodrama is a means of cure for individuals." Many individuals have changed the original meaning so that in addition, sociodrama refers to the dramatization of a social problem, an issue or a situation, in order to make it clear so that individuals may better solve the problem and at the same time change their behavior. In any event, it is clear that the goal of psychodrama or sociodrama may be thought of more in terms of therapy than instruction, even though both techniques involve enacted responses. Control is minimal, and the sociodrama or psychodrama is more or less free-wheeling. They should probably be thought of more as techniques related to contextual response simulation.

It is more difficult to dismiss role playing as a type of contextual response simulation. First of all, authorities define the term differently. Some take it to mean the same thing as sociodrama. Others talk of role playing as the depiction of characters in scenes for illustrative purposes in which case it would qualify as referential simulation. For example, an instructor may stage a proper interview approach in a course of training a team of research workers (cf., Katona 1955). A sociodrama would differ from role-playing in that a group would enact the scene, not the instructor. Others equate role-playing with "let's pretend" or "play-acting" (cf., Garvey, 1967). Grambs, (et al., 1958) defines role playing as "unprepared, unrehearsed dramatization." However, they are quick to point out that the technique of role-playing is mainly concerned with the development of deeper understanding of social relations. For example, a particular social issue may be, "If the United States has a surplus of food, to what country should it go and under what terms?" The authors point out that the teacher may assign some members of the class to various roles of spokesman of various countries, United States officials and diplomats, and so forth. Each present their point of view, and when the experience is ended, certain concepts were developed about foreign viewpoints.

Chester and Fox (1966) give the example of a teacher who attempts to solve a problem in interpersonal relations by using role-playing. Two children are asked to take the part of fourth-graders, and two children are asked to take the part of sixth-graders. The plot is simple. The fourth-graders have bent a runner on a sled so it doesn't work. Some sixth-graders appear, each with a new sled. What should they do? The teacher has set the stage for conflict.

In both examples, it should be noted that the majority of the class witnesses the role-playing. Only a few students actually participate. Role-playing is followed by a discussion involving the entire class. Role-playing does not involve simultaneous participation of all class members. Most class members are observers of the depiction of characters. Because of this factor, role-playing is probably best thought of as a technique related to contextual response simulation.

Case Studies. Typically, the case method presents a problem situation from the perspective of the learner. Either complete information that represents all that is available or incomplete information that requires the learner to seek out additional relevant information may be given. The problem situation may be quite lengthy, or it may be quite brief, (for example, the Incident Process as developed by Pigors and Pigors (1961). Usually, the case is discussed in a group situation with the members participating in seeking solutions to the problem, and relating the problem to other course materials, Foster and Danielson (1966) suggest that "because the case is generally written so that members approach the problem from the perspective of a person in the case, the method may be viewed as nonbehavioral or passive form of role-playing." The goal of the case method is clearly to bridge the gap between theory and practice through simulated experiences that are encountered in real life. The instructional objectives of the case method, seem rather complex. They do not deal with the acquisition of knowledge as much as the

> "development of the ability to analyze realistic problems and to master the tangle of facts and circumstances that suggest conflictive solutions. Through his involvement

the trainee comes to learn that solutions are not as obvious as at first they might appear, that more information is needed than he may initially tend to believe, and that everyone does not perceive the same set of events in what seemed to him to be the obvious way" (Foster and Danielian, 1966).

The interesting thing about the case method is that there are no right answers. Principles that are appropriate in one problem situation may not be appropriate in another. According to Foster and Danielson, "The basic purpose is to learn how to deal with certain types of problem rather than to learn a set of solutions *per se*." More attention is given to the process of how solutions were arrived at rather than the content of the problem. The case method has been used for some time in law schools and medical schools, and in a wide range of courses such as political science, public administration, management training, research methodology in sociology, and legislative processes (cf., Westin, 1962; Stein; 1952; Tillett, 1963; Const, 1957; Riley, 1963).

Does the case study represent a contextual response simulation? Although overt behaviors commonly associated with learning games or simulators are not present in case studies, the learner is exercised in decision-making and problem solving similar to that required in real life situations. In this sense, the criterion of enacted responses is met, at least in terms of these specific behaviors. The provision of feedback is tenuous at best since no right answers exist, and it is difficult to tell whether the strategy being employed to arrive at a solution is indeed the appropriate one. The Incident Process (Pigors and Pigors, 1961) is an attempt to systematize the provision of feedback to some extent, but even in this case, it is primarily limited to providing additional information on the case rather than attempting to direct or reinforce the process of decision-making or problem-solving. Of course, the subsequent discussion or critique (debriefing) at the end of the information-gathering period also provides feedback, but here again the emphases is on what processes affected the decision making rather than on the most appropriate process that would lead to the best decision-making.

Academic Games. Simulation games, educational games, learning games, games with simulated environments, simulations, and simply games, are all terms that describe this technique. Since games are usually thought of in terms of entertainment, often the word, "simulation" is added to make the technique appear more respectable. Yet, a simulation game, in a sense, does entertain by the use of competitive activity among the players. In the well known family game of Monopoly, players compete with each other for properties and the eventual wealth that comes from owning hotels on strategically located places. An example of an extension of this game to business is the American Management Association management-decision course. Abt (1966) defines a game as "any contest (play) among adversaries (players) operating under constraints (rules) for an objective (winning, victory, or pay-off)." Nebsitt (1968) presents a less formal definition: "a game might be defined as something enjoyable -- however serious -- involving competition for specified objectives and observing rules." It is quite possible that games for learning are outgrowths of war games such as chess and similar board games. (cf., Weiner, 1959; Young, 1956). Abt (1966) points out that war games "were probably originated by military practitioners for their part-amusement, part training." An officer playing a war game not only is challenged to win, he may, in the process of the game, learn certain military principles. There is little doubt that the wide acceptance of learning games in education today is related to this phenomena of learning something while enjoying it. In an interview with high school students who participated in several games at Clark County, Washington Instructional Games Workshop, a question was asked of one student, "Did you do more homework than usual to play the game?" The student answered, with a puzzled look, "Gee, I never thought of it as homework!" In short, the learning game proves that instruction need not be boring by actively involving the student in simulations that are relevant to the student's own life. Since most students enjoy games, and receive considerable satisfaction from them, the use of games for academic pursuits is one way to assure student motivation while at the same time teaching.

Are learning games to be considered as contextual response simulations? Clearly, most games involve enacted responses to the non-real life situation. Further, students oftentime receive very quick feedback as to whether or not their responses are effective or ineffective. This feedback usually comes from peers rather than teachers, as was stated above. The matter of control is difficult to assess in learning games. Yet, in comparison with real-life situations, there is enough control in the simulated environment so that the same game may be played time and again with predictable results if proper attention is given to administrative details. Most simulation games can certainly be termed a contextual response simulation. An exception to the rule might be some of the "academic games" developed by the Nova Academic Games Project. Some of these games clearly are not simulations, but simply provide experiences that are competitive in nature.

In-basket technique. The in-basket approach has become widely used in recent years for testing and training administrators in business and education. The materials for instructional purposes have been developed through the University Council for Educational Administration (Frederiksen, Saunders, and Ward, 1957; Frederiksen, 1962; Hemphill, Griffiths and Frederiksen, 1962). The learner's task is to consider various messages that come to him through his in-basket and decide what responses he should make that would be most appropriate. Some items may be delayed or discarded since they are trivial; other items are far more important and require immediate attention. Each communication involved the learner in either searching for information (discussing, investigation, asking opinions and advice from others), or giving information (issuing directives, giving opinions, citing rules, acknowledging events). In some cases, the learner is involved in making enacted responses to non-real life situations. Other times, the learner writes what he would do. The matter of feedback in an in-basket situation is also tenuous. Present techniques are limited in the type and amount of feedback which may be presented to the learner, since all possible unanticipated consequences of a learner's responses have not been specified. Bessent (1967) does describe a feedback sequence for the requesting information mode that utilitizes a computer-assisted format. The author concludes that no major problems exist with the feedback procedures as long as the learner is searching for information. When the learner is given information, limitations are encountered. However, the feedback procedure described by Bessent offers a promising approach to the extension of the in-basket technique.

Classroom Simulation. The technique of Classroom Simulation as developed at Teaching Research has been cited as an example of a simulation used to elicit life-like responses. Indeed, the prototype situation is clearly an example of a contextual response simulation. It is important to realize, however, that variations in the classroom simulation technique may remove it from the arena of contextual response simulation. For example, in one mode that has been developed with new "low-cost" materials, a student sits at a study carrel and writes out her answers after covertly responding to a filmed episode. Clearly, a covert response is not an enacted response, that is, a life-like response performed in a non-real life situation. Yet, all of the other features of the simulation are similar to the original Classroom Simulation.

The educational techniques that have been discussed above show the difficulty of positively stating that one thing is a "contextual response simulation" and another is not. There are clear cases where a technique fits the definition. Other cases are questionable. The criteria for labeling a technique a contextual response simulation, and several examples of classification are presented in Figure 2. The question marks in Figure 2 reveal cases where the criteria is unclear without specification of the instructional conditions by the user. For example, classroom simulation (cf., Twelker, 1967) may not be a contextual response simulation by this definition if symbolic or covert responses are used.

Two Crucial Considerations

Transfer

Transfer is a term that is almost as difficult to define as the term simulation. In its conventional usage, transfer occurs whenever a previously learned skill or habit or behavior influences the acquisition, performance, or relearning of another skill at a later time. When

Technique / Characteristic	Moot Court	Role-playing	Sociodrama Psychodrama	Academic Games	In-basket Technique	Case Method	Classroom Simulation	Link Trainer	Models	Instructional Films
1. Enacted response are involved	Yes	For Some Students	Yes	?	Yes	Yes	?	Yes	No	No
2. Feedback is provided in an-going instructional context	Yes	?	?	Yes	?	No	?	Yes	No	No
3. Stimulated situation is reproducable	Yes	?	?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Figure 2. Characteristics of contextual response simulation

performances on the second task (the "transfer task") is facilitated, it is said that "positive transfer" has occurred. When performances on the second task is inhibited, it is said that "negative transfer" has occurred.

Gagne (1965) talks about two types of transfer. One type makes it possible for the individual to perform in a way that is not directly learned, but is in some sense similar to what was learned. Consider a population of situations, all of which represent only one class in terms of the operations involved. For example, imagine a population of cryptograms, all of which are different in terms of the symbols used, but which could be solved by applying the same rule or principle. Or consider a population of toggle switches, all of which require the same movement to activate a machine. In terms of this type of transfer, a "one-to-many" relationship is involved: one operation pertains to many situations. Gagne terms this type of transfer "lateral transfer," since it refers to a kind of generalizing over a broad class of situations at about the same level of complexity.

A second type of transfer Gagne terms "vertical transfer," which involves the application of subordinate principles previously learned to the learning of additional principles at higher levels. The key to satisfactory vertical transfer is the mastery of the subordinate principles or capabilities.

It would seem appropriate, when considering simulation, to think in terms of a third type of transfer that might be termed "horizontal" or "parallel" transfer. This involves the transfer from the instructional conditions to the testing of transfer conditions when the situation and operation required in the second task is equivalent to that taught previously. That is, the operation required in the transfer situation, which may be a real-life situation, by the way, differs from that taught in the instructional situation only in terms of what might be called a simulation continuum. For example, if the instructional conditions used an iconic situation and involved enacted responses, the transfer situation might also involve the same modes. In this case, no parallel transfer would be required since the transfer conditions and the instructional conditions were essentially equivalent. On the other hand, if the transfer condition involved the real-life situation (and hence a real-life operation_ then parallel transfer would be involved since the subject was instructed under different conditions (that used simulation). Also, if the transfer situation were a paper-and-pencil test, parallel transfer would be involved since the subject must then transfer from the enacted response to the symbolic response and from the iconic stimulus to perhaps a symbolic stimulus. In short, parallel transfer involves the learner in simply moving from the instructional situation to a parallel transfer situation which involves the same situation, and the same operation. The only difference is that when the skills or knowledge were learned, the conditions were different than when the subject was tested.

The characteristics of the three types of transfer, lateral, vertical, and parallel, are summarized in the figure below.

Type of Transfer	Situation	Operation	Characteristic
"Parallel"	Inform-ationally Equivalent	Operation-ally Equivalent	S applies same operation to same situation in the transfer condition as in instructional condition. Testing condition may be more or less realistic.
"Lateral"	Member of Class of Situations	Operation-ally Equivalent	S applies some operation to members of a class of situations.
"Vertical"	Member of new Class of Situations	Different	S generates new operation from previously learned operations.

Figure 3. Testing (Transfer) Task as Compared with Instructional Task

Now it is not too difficult to see how the consideration of parallel transfer is important when a role-performing simulation exercise is developed. A prime objective of such a simulation is to have the learner operate as though he were in a real-life situation so that he will perform in the real-life situation adequately. This is true of complex aircraft simulators, some in-basket techniques, and probably certain learning games where the role that is played is the same as that to be performed in real life.

It is more difficult to see how the consideration of parallel transfer is relevant to the design of role-assuming simulations that characterize many learning games. However, recall that the characteristic of parallel transfer is that the learner applies the <u>same</u> operation to the same situation in the transfer condition (which may be real life) as in the instructional condition. For example, an administrator is taught to make decisions in an in-basket technique, and these skills are meant to transfer to real life. That is the point of the simulation exercise, and in fact, is inherent in role-performing simulations. Now, when roles are assumed in an academic game such as a foreign policy game, the learner or role-player is usually uninformed, as Cohen (1962, p. 374) points out, and possibly too inexperienced or culture-bound to play the part of a leader of a foreign nation, for example. It can be seen that in this situation, there may be little more that the student can do than merely play the role on hunches and intuition. The implication, in terms of parallel transfer, is that the learner may be applying different operations to somewhat similar situations in the instructional condition as would be the case in the transfer (and possibly real-life) condition, the difference depending to a great extent on the prior knowledge he has of the role that is essential to the playing of the role. This condition has led some writers, such as Kraft (1967) to argue strongly against learning games as being non-realistic because the operations performed in the game, e.g., a two-minute "negotiation" in a legislative game, are not typical or representative of real life, in terms of the actual complexities in real life. Bloomfield and Padelford (1959) indicate that some game members found their roles in a political game difficult to play. Cohen points out that most students, graduate as well as undergraduate, suffer from a "knowledge gap" which prevents them from playing the role of a real-life counterpart. Further, Cohen states that

> "even if a player knows the role he is playing, about the objective foreign-policy situation, and about the political environment of policy-making - which are all unlikely contingencies - the probability that he will behave in a manner that is indicated by that role is rather low" (1967, p. 376).

It can be seen that parallel transfer not only involves performance in an operational situation, it involves knowledge of facts, principles or relationships of an operational situation. Supposedly, what is taught in instruction must fit real life. If there exists a "creditability gap" between instruction and the operational world, then the learner is at a disadvantage when it comes to either performing in the real world, or understanding what the real world is like.

This writer once played a non-computerized business game where the team made a set of decisions and recorded them on a form that was sent to analysts. The analysts were responsible for returning information that spelled out the consequences of the decisions made by the team. This sequence was repeated for several periods. It quickly became evident to the teams that something was amiss in the running of the game when actions and consequences didn't make any sense. Two teams might decide on similar courses of action, but one would be rewarded with sales while the other would be profitless. The teams soon learned that the reason for this was that the analysts tossed a coin to decide the fate of the companies. The model was inadequate to cope with the complex factors of the game, and chance was allowed to play a major role rather than a minor role in the specification of consequences. A "creditability gap" existed between the real world and the game that simulated the real world. It existed to such an extent that participants could not predict what business moves led to what outcomes since the probability was 50-50 that the outcome would be negated by the toss of the coin. What is taught in this type of game is probably minimal. Cohen and Rhenman (1961) quote Martin Shubik at a national conference on management games whose remarks are pertinent here:

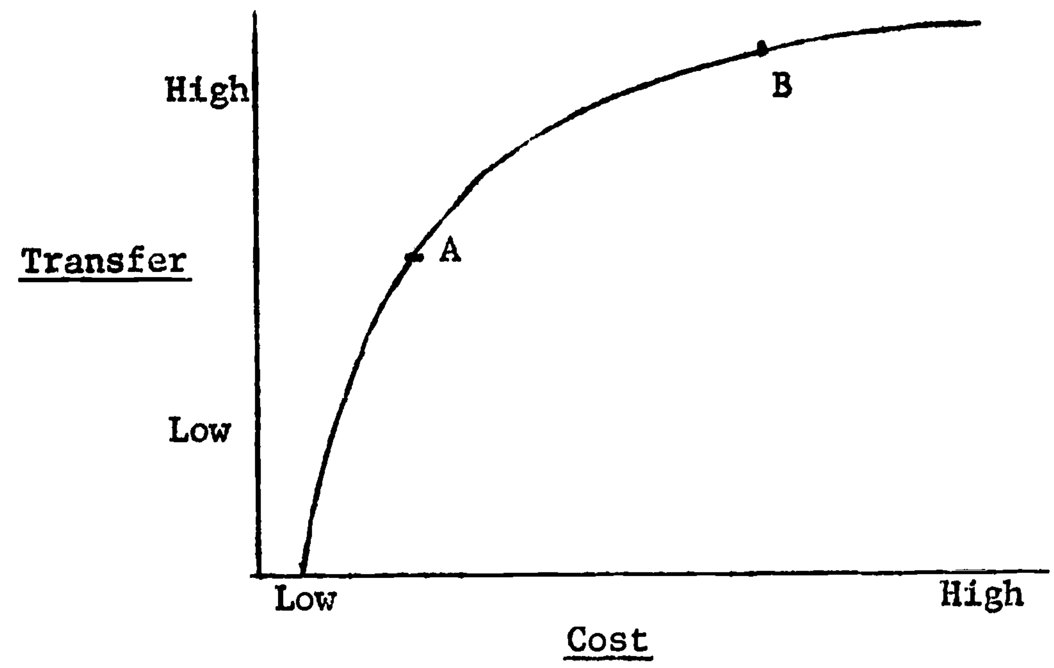
> "I wonder if the speakers who have spoken so far have actually had any specific purpose in mind. Have you gentlemen had one or two general hypotheses? Do you have any specific purpose other than that everybody has a whale of a time in playing these games?"

It behooves the designer of simulations to at least consider the factor of parallel transfer. The designer must assure the student of learning the same operation or the same facts that are applied or used by others in real life. Otherwise, that learner is at a disadvantage when it comes to understanding the real life world. Now this caution is not limited to role-assuming simulations. It is conceivable that in role-performing simulations, the student does not have the appropriate entry behaviors necessary to perform in the simulation as though it were real life. This may have been a drawback of the original classroom simulator as developed at Teaching Research (Kersh, 1963a; 1963b; 1965; Twelker, 1967). Students didn't have the necessary knowledge initially to handle the many problematic situations, and the technique was unable to draw these behaviors out of the student except through a tedious question-and-answer session. The simulation did not <u>exercise</u> previously learned principles of classroom management, but taught the principles through a discovery process. As a result, training time was excessive for many students. The new instructional simulation materials developed at Teaching Research <u>teach</u> some basic principles of classroom management directly, and then <u>exercise</u> the student in the application of these same principles. Without this two-step process, it could not be assumed that the operations that were being applied during instruction would transfer to real life.

One crucial question in regard to transfer is: Does exact physical duplication of the stimulus and feedback situations guarantee maximum positive transfer? The research literature does not have a precise answer to this question. On the one hand, older studies on transfer of training have shown that the more similar two situations are the more transfer will occur from the first situation to the second situation. For example, Bugelski concludes that "...experimental findings indicate that positive transfer is a function of the degree of similarity between stimuli (if responses are the same" (1956, p. 408). As a result, we have seen an abundance of so-called "high-fidelity simulations", some of which are so complex that entire teams of operators are required to monitor the experience. On the other hand, later studies have placed doubt on the maxim, "For maximum transfer of training, use perfect fidelity or realism". There is some evidence to indicate that for complex skills, greater transfer is produced by a systematic arrangement of <u>practice</u> than by high-fidelity <u>physical</u> simulation (Gagne, 1962; Cox et al 1963; Gryde, 1966a; Crawford, 1962; Smode, 1963; Newton, 1959). In fact, for tasks of high difficulty, it is probably more advantageous to use simulation to simplify the instructional conditions as it is to use a real life situation in hopes to increase positive transfer. By using simulation, time may be compressed or expanded, feedback may be augmented, emergencies may be introduced, guidance may be used to limit learner errors, task variety may be introduced (as an aid to lateral transfer), and practice may be distributed (cf., Smode, 1963, p. 97-98).

Unfortunately, even if a simulation designer did know how to design the system for maximum positive transfer other factors must be considered. For example, the designer must consider trade-offs between transfer and cost, primarily. Further, trade-offs between transfer and safety, special training, provisions for feedback, must also be considered.

The trade-offs between transfer and cost or economy is illustrated in the figure below. The curve shown is a hypothetical relationship between amount of transfer and cost of a simulation. Point A illustrates a trade-off between providing for a medium amount of transfer at a relatively low cost. If economy is not an important factor, the designer may choose to accept a high cost-high transfer relationship as shown as Point B.



It should be made clear that this discussion has not attempted to define either cost, or the way that transfer is measured. These are problems that must be worked out by the simulation designer. Suffice it to say, there is no easy way to define cost, since it may involve cost per student hour, cost per unit to produce, cost per unit to sell, and so forth.

In summary, it should be realized that exact physical duplication does not guarantee maximum positive transfer. Recall that Gagne insists that the most important thing is to determine the operation to be taught, and then specify the conditions to bring about the learning of that operation so that the student will perform in the real life situation satisfactorily. Muckler, et.al., (1959) also points out that transfer will be greatest when there in psychological fidelity, that is, when the skills taught in the simulation experience are the same as in the real-life situation. For a more complete overview of the state of the art in regards to transfer and simulation design, the reader is directed to discussions by Miller (1953), Gagne (1962), and Gryde (1966a.).

Motivation

Another factor that seems to lie at the heart of simulation is motivation. Sprague (1966; and Shirts, 1966) states that the involvement of students in learning games causes inquiry and discussion after the simulation. Abt (1967) cites increased student motivation as one of two primary "pay-offs" with education games and simulations. Cherryholmes (1966) reviewed six investigations of educational simulations and concluded that simulation produced increased student motivation and interest. Walter Cronkite, in a CBS documentary suggested that "by participating by playing a game, an otherwise dull subject becomes fascinating and unforgettable to the students".

Why is simulation motivating? Clark Abt suggests that the reason is that there is increased student motivation because subjects of topical relevance to the student's own life are selected and because students actively participate in the simulation. He adds the following insights:

> "A great deal of our substantive content is not perceived by the student as relevant to his own life, however much we might feel that it is and should be so perceived. A great deal of the material, whether perceived as relevant or not, is not actively responded to by the student. We would like to introduce the active response mode that has been so successful in the area of the physical sciences into the social studies area. We would like to introduce essentially a laboratory method, and we would like to do this with material that is perceived as substantially relevant to the students' own life. We believe the educational games and simulations achieve this objective, of giving the student a feeling of the relevance of the material to his own life and of enticing him into active engagement with the material." (cited in Twelker, Crawford, and Wallen, 1967).

Smode et al., (1963, p. 99) introduces the term, "motivational similarity", as that which is concerned with the feeling or attitude of the learner in a simulation experience as compared with a feeling experienced in real life. Smode's orientation is principally that of a military trainer of aircraft operations. As such, a primary factor in motivational similarity is the realism of the simulation. It is conceivable that a simulation might be designed that would produce optimal transfer except for the fact that its lack of realism causes the learner to disregard the instructional experience because of its obvious falsity. If lack of motivation results, then measures must be taken to assure the proper conditions for instruction to be effective. To this end, physical similarity must be added to the two factors of relevance and activity mentioned by Abt. It goes without saying that this does not contradict the emphasis given by Gagne to the specifying of operations to be taught before physical conditions of realism are considered. It does point up the fact that even though operations are the crucial thing in designing simulations, the stimulus and feedback situations must not be ignored lest the conditions be inadequate for eliciting the desired responses on the part of the learner.

One word of caution must be given when considering the physical similarity of a simulation, and this is relevant in designing a learning game as well as a complex simulator. The design of simulations is often times influenced by a desire to make them "more appealing" and "interesting" to learners and this usually takes the form of increased realism of non-essential elements. If properly done, it adds to the effectiveness of a simulation. It motivates the student, and he regards the experience as meaningful and relevant. On the other hand, simulation designers often resort to "gimmicks" or what Lumsdaine refers to "fancying up" the device or technique which may cause distractions that may "interfere with the attention of the student to the essential task to be learned, and thus have an adverse effect on learning rather than a beneficial one" (Lumsdaine, 1960, p. 283).

Smode points out that motivational similarity is a function of the entire instructional program. Thus a fourth factor emerges: administrative or management considerations of instruction. The way in which the simulation experience is scheduled, the way in which the experience is utilized, the quality of the instructor, the "set" given to the students by the instructor, the "debriefing", and the development of the syllabus all affect motivation. Inbar (1966) has shown that the size of the playing group stands out as a crucial variable in the differential effectiveness of a learning game.

> "In overcrowded groups the players learn the rules of the games less efficiently, interact less, are less interested in the session and participate less actively in it; as a consequence they tend to play a lesser number of moves and the impact of the game is weaker" (Inbar, 1966, p. 26).

In the Disaster Game, Inbar found that nine was the breaking point, but it should not be inferred that this number holds for every game. Cohen (1962) also points out in a foreign policy game, the size of the class had an important bearing on the size and composition of a particular team, which in turn affected the play: a large team produced lethargic play, and affected the game adversely.

Another very interesting finding by Inbar was that the first few minutes which preceded the beginning of play is of utmost importance for the inducing of interest and participation in the game. Some twenty per cent of the explained impact of the game was accounted for by activities in these few pre-game moments when the rules of the game were read and discussed.

Parker and Downs (1961, p.34) present other evidence that points to the importance of pre-simulation activities in the context of a flight simulator. They cite an unpublished study by Solars et al. (1953) where one group of students were told how the differences in fidelity between the simulator and the operational aircraft made the trainer practically worthless. Another group of students were told that these differences existed but were of negligible importance in the value of the experience. Thus, the "set" given to the two groups of students differed, and in fact, an attitude scale showed that the groups' acceptance of the simulator was indeed quite different. In actual performance on the aircraft, however, the negative attitude and the positive attitude groups performed equally. But, the negative attitude group required more trials to criterion and hence more training time. While lack of simulator acceptance lengthened training time, it has little effect on parallel transfer from the instructional situation to real life.

Now it is difficult to speculate on the implications of the study to the conduct of simulations. Muckler (1959) points out that the pilots were highly motivated to perform at a very high level of competency and this motivation may have overridden any decrements from the negative attitudes toward the simulator. It would be interesting to repeat the study with different classes of students some of which were highly motivated in the general sense to succeed, and some of which were potential dropouts. In this case, the factor of set may be shown to be quite important for transfer performance as well as instructional performance. In any event, the evidence presented by both Inbar and Solars is but an indication of the importance of attending to pre- and post-simulation details. In fact, this writer suggests that a manual for a contextual response simulation should include the specification of these activities as precisely as those that are commonly thought of as the simulation experience itself. In fact, Cohen (1962) suggests that physical layouts, and even the weather may affect game play, often adversely. Bloomfield and Padelford (1959, p. 1111) suggest that too close a proximity of teams in a game may deter or complicate role-playing and the maintenance of adequate security, and may unrealistically speed up the dimensions of time. Certainly, careful attention must be shown for all of the administrative considerations of conducting a simulation.

A fifth factor that should be mentioned in regard to motivation is that of stress. Stress was mentioned above as an important contextual variable. The learners' perception of stress may make the difference between his perception of simulation as relevant and realistic or irrelevant and unrealistic. It goes without saying that a characteristic of learning games is the amount of stress that is placed on the student to perform, sometimes in difficult circumstances under limited periods of time.

Stress may be produced in the instructional simulation in several ways. First, learner overloading may produce stressful performance. The learner may be overloaded by presenting him with too many signal inputs that demand him to make an excessive number of responses in a given period of time. The rate at which a learner may receive information is dependent upon the input difficulty, learner ability, and rate at which the input is presented. For example, a learning game involving a political emergency may be designed to produce stress by simply increasing the number of messages to the participants that in turn require them to make an excessive number of responses in a given amount of time. Whether or not the instructor wishes to do this is dependent upon his objectives. If the instructor's objective is to exercise the students in making quick decisions under adverse situations, such techniques of learner overloading to produce stress may be used.

A second way that stress is produced is the opposite of learner overloading. That is, the learner is "underloaded" so that stimulus input and response outputs are few and far between. Such sensory deprivation produced monotony and under conditions of confinement and isolation, stress, where performance definitely tends to break down.

A third way that stress may be generated is by means of unexpected stimuli and emergencies. These situations require immediate attention over and above that required in the normal functioning of the simulation experience. It is interesting to note that even the threat of such unexpected stimuli or emergencies is often times enough to produce the behavior characterized by stress. It is also interesting to note that a certain amount of this type of "pressure" seems to be necessary for learning to occur, especially when the learning situations are not complex.

It is a different story when complex learning situations are involved. Under such conditions, stress may produce errors, time lag, learner rigidity and other behaviors characteristic of non-adaption. A phenomenon called habit regression may occur when older responses that have no use to the individual and presumably have been extinguished may reappear.

The interaction of the various factors with the success of the instructional experience is illustrated by Smode (1963, p.118). He describes a situation where an aircraft simulator resembled quite closely the operational aircraft in function. However, students perceived it as being unrealistic because it was too unstable and hence more difficult to fly than the real aircraft. Tests showed this to be false, and pointed up the problem as one of motivation. Students did not give their undivided attention to "flying" the simulator as they would have in a real aircraft. A momentary lapse of attention caused the student to "get behind" the craft and cause it to go into instability. Such lapses occurred in the simulation experience because motivation was low. These lapses would not occur in the real life aircraft because motivation was high. So what was blamed as a problem of faulty dynamic simulation was actually due to faulty motivational similarity.

What's the Use of Contextual Response Simulation?

Why use contextual response simulation? What does the learner gain by participating in such a simulation? If there are certain benefits or "pay-offs", then how can an instructor in biology or history or psychology, for example, realize these benefits in his own courses. Are some training functions better served through simulation than other training functions?

One problem that is faced in answering this question is the great variety of simulations available. One would not expect that benefits derived from the appropriate use of learning games or other "role-assuming" techniques to necessarily be valid for skills training or role-performing techniques. For example, a primary objective of games as educational devices, according to Schild (1966) is to have the student learn "strategies and skills conducive to winning the game". This benefit probably is limited to certain games and is not appropriately thought of as a benefit of other games or role-performing simulations such as the Classroom Simulation as developed at Teaching Research.

A second problem that is apparent when attempting to identify the use of simulation is that a particular benefit may or may not be realized in a particular simulation, depending on factors such as game administration, learner abilities and characteristics ("entry behavior"), and even instructor incompetence (cf., Inbar, 1966, p. 26). In other words, games *may* teach winning strategies but only if they are constructed and administered with this objective in mind. The playing of a game does not automatically insure the learning of winning strategies, just as the reading of a book does not necessarily insure the acquisition of facts.

This is dramatically illustrated by Inbar (1966) whose research reveals that "inducing interest in the simulation and enhancing willingness to participate voluntarily in the session are probably the variables which are the most readily influenced by the person in charge of presenting the game". Inbar concludes on the basis of this and other evidence that "the person in charge of the session is of tremendous importance, at least for games which are not readily self-taught and/or self-administered".

With these problems in mind, let us turn our attention to some of the learning outcomes that may be achieved through the use of simulation. It should be recognized that in many cases, little or no evidence is available to support what amounts to intuitive hunches. It should also be noted that examples are given for illustrative purposes only and are not meant to be inclusive of all simulations that may be used for a particular training function. Finally, only a representative number of training functions are discussed.

What may be Learned from Simulations?

Winning Strategies. It was mentioned above that winning strategies may be taught through games. In fact, Schild (1966) suggests that "the learning of strategies has in a sense priority over other possible learning" and is where "the game is likely to have the strongest impact". Research on the Disaster Game by Inbar (1966) reveals that strategies are learned in addition to the problems involved in the simulated situation. Boocock (1966) found that players of the Legislative Game "do acquire strategic sophistication" from the game. About three quarters of the students answered correctly the question of what they thought the most effective strategies were for doing well in the game. Unfortunately, neither Inbar or Boocock present data to show that the students applied the winning strategies, in fact, to win the game. Further, this writer suspects that few games are designed with this objective explicitly in mind. Often, individuals are kept from learning the strategy in games of entertainment to "load the dice" against a naive player's winning and this attitude may prevail in games of learning. Of course in some games, the winning strategies are unknown or at best speculative.

It is interesting to note that the learning of winning strategies is not always paid attention to by evaluators of learning games. Cherryholmes (1966), in his review of current research on the effectiveness of educational simulations, does not list the learning of strategies among the five outcomes he studied. Western Behavioral Science Institute (1966) fails to mention the learning of winning strategies in their list of "hunches" about the uses of simulation. Bloomfield and Padelford (1959) indicate that skills, at devising optimal strategies could be scored in the games they conducted in the area of political science, but were not.

Principles and Relationships. The use of the term "learning game" implies that something is learned. Abt (1966) clearly states that the objectives of learning games are "to educate, not to entertain". Many games, according to Abt, offer "the greatest educational potential for student comprehension of structural relationships (and) the problems, motives, and methods of others". For example, the game of Seal Hunting teaches about the interaction between seal and Eskimo in a hunt. The game of Hunting involves students in learning facts about the primitive social organization and ecology of the Bushman in the Kalahari Desert. Empire is concerned with the 18th century British Empire and exposes students to factual information such as the trade laws, the London monopoly, prices and tariffs. The legislative game developed at Johns Hopkins University (Coleman, 1966) is designed to teach "the basic structure of representative government".

Cherryholmes (1966) reviewed findings from six simulation studies to assess the hypothesis that "students participating in a simulation will learn more facts and principles of information than by studying in a more conventional manner." Without exception, none of the six studies presented evidence to support the hypotheses. Cherryholmes notes that Garvey and Seiler (1966) found that the control group who received lectures and discussion in lieu of simulation actually performed better on the tests designed to measure acquisition and retention of factual and conceptual knowledge. However, examination of these data reveal that none of the differences were statistically significant. It also should be noted that the above-mentioned evidence does not indicate that learning games do not teach, but simply that they do not teach better than other types of instruction. The question that arises, of course, is whether or not the time it takes to play a game is offset by other benefits gained from games that are not found with other instructional techniques, e.g., increased interest in the subject matter.

The learning of factual knowledge (e.g., the meaning of words and symbols, rules and principles, and relationships) is considered by some as a secondary training function of simulators. Demaree defines a simulator as "a relatively complex item of equipment utilizing primarily electronic and mechanical means to functionally reproduce operational conditions to the extent necessary to accomplish the operational mission of an individual or aircraft". Parker and Downs (1961) list the understanding of principles and relationships as a quite appropriate use of a simulator granted it is programmed properly. It should be noted that the use of a highly complex and costly simulator for learning conceptual information may not at all imply that it is the best way to use such a piece of equipment. In many cases, an instructional film or even a chart may teach a principle as well as a complex simulator and at a much less expensive cost. Gagne (1962) points out that the optimal function of a simulation is in the later stages of training, not in the early stages when the learning of prerequisite knowledge is probably most important.

Decision-making Skills. One of Western Behavioral Sciences Institute's (1966) "hunches" about simulation games is that their "primary value is that they teach students how to be more skillful decision-makers". The reason given for this is because students are required in a game to make frequent decisions under pressure, and "they seem to increase their ability to do this within a few hours time.

One of the objectives of most management games is to increase the capability of students to make decisions (e.g., Cohen and Rhenman, 1961; Fulmer, 1963; Dill, 1961). Peter Winters (reported in Twelker, Crawford, and Wallen, 1967) describes a special purpose game for use in a course called Production Management, where students are required to make forty-eight decisions in each of several periods. The unique feature of this game is that the decisions are made or stated by writing a computer program so that the student must be quite specific about his policies. In fact, Winters looks upon this experience "not so much as a game as more research with decision-making".

Demaree (1961) points out that complex decision-making mission-oriented decisions under real time simulation of instrument readings is probably best trained by exercising these behaviors in a life-like setting where the learner may receive immediate feedback as to the adequacy of his response. Parker and Downs (1961) also report that a simulator that includes all of the necessary cues and occasions for the training of decision making is useful if it is properly programmed. As noted above, these writers think of simulators primarily as aircraft trainers. This writer has also noted that increased decision-making skills may be one benefit of classroom simulation training. Students may make decisions about how to handle typical classroom problems, often weighing the consequences of one response against the other (Twelker, 1967). Several studies have shown a definite improvement in the student's handling of the problems after training, as measured by the presenting of novel filmed episodes. Little evidence is available to show that this decision-making skill is transferred to real-life situations.

In the review of the six game evaluation-studies, Cherryholmes concludes that simulation games do not cause students to acquire more decision-making skills than conventional classroom activities. Although Garvey and Seiler (1966) reported that, in one instance, the control group performed significantly better than the experimental (simulator) group, Cherryholmes rejects this evidence as does Garvey and Seiler, on the basis that "the results across group and schools were not consistent or large enough". Although this writer hesitates to relegate statistically significant differences to the realm of sampling error, without at least considering other alternative hypotheses, it is nevertheless clear that games are probably no worse or no better for exercising decision-making skills. It should be noted that Garvey and Seiler did not attempt to measure the quality and speed of decision-making in the game itself. If games did teach decision-making, gains might be noted over a series of games.

Identifications. An important skill that may be taught by the use of contextual response simulation is the learning to identify important cues, signals, and other stimulus situations. Parker and Downs (1961) define "learning identifications" as the "pointing to or locating objects and locations, naming them, or identifying what goes with what -- either physically or in words or symbols". Demaree places the learning of perceptual identifications, and naming and locating as a secondary training function of simulators, which essentially means that a simulator may be used for such purposes, but it may not necessarily represent the most economical approach to this training. This opinion reflects the narrow meaning that Demaree, and Parker and Downs for that matter, attach to "simulators".

It should be pointed out that the identification of cue patterns may certainly be taught by other than contextual response simulation. A chart (a referential simulation) may be quite adequate for teaching a student to identify, for example, various varieties of resistors. However, when this skill must be used in the operational situation, and all sorts of "noise" is likely to be encountered in the system, a simulator may be useful in exercising the learner in his discrimination skills in the operational situations. It is one thing for a novice to "read" Morse code in the classroom. It is quite a different thing to require that individual to perform when unusual messages are presented during various disturbances that may occur on the battlefield. (cf., Miller, 1962).

Procedural Sequences. Parker and Downs (1961) suggest that this training function represents the most effective use of a typical simulator. We point out that is especially effective in the training of the emergency procedures where practice on the simulator may bring the learner to a high state of proficiency. Demaree (1961) also lists the procedural sequences as a primary function of simulators. However, the term, "integrated task performances" is used rather than procedural sequences. No evidence is presented in either report that would serve to substantiate the use of a simulator rather than other techniques.

Skilled Perceptual-Motor Acts. A discussion of learning outcomes would not be complete without the inclusion of this training function. By and large, the two most widely used applications would be (simulated) aircraft flying and automobile driving. There is some data to show that gains do result from the use of simulation, although not necessarily in increased proficiency. For example, Flexman, Townsend, and Ornstein (1954) report that students trained in an aircraft simulator received thirty hours less flying time than a non-simulator group, but proficiency was equal to or better than the non-simulator trained group. Thirty hours flying time represents a substantial savings in money with no appreciable decrease in effectiveness. The authors do point out, however, that the simulator was better suited for training certain maneuvers heavily loaded with procedural components. This limitation could have been a function of the particular simulator and training program.

In Conclusion

In one sense, simulation does not represent as much a tangible thing or process as it does a philosophy. This philosophy is best thought of as a fusion of two worlds - the instructional world and the real-life world. In the instructional world, the overpowering tendency for the instructor is to present information, this information often being piled upon the student in illogical sequence and overabundance. Little regard is given to the student in terms of the real-life world. Yet, Fitzgerald states that:

> "the task of intelligence is more than that of a warehouse employee picking stock down the aisles, more than that of the novitiate reciting a long catechism of correct answers. Learning is also insight, inquiry, emergence, the development of any critical faculty, and an intuition of a web of interdependent hypotheses and influences, the structure of abstractions about the seen and unseen, that comprise our understanding of the physical world. Learning is also exploring, conceptualizing, experimenting, interacting and valuing." (Fitzgerald, 1962, p. 247-256)

Schwab (1961) adds that the aim of a completely enquiring classroom

> "is not only the clarification and inculcation of a body of knowledge but the encouragement and guidance of a process of discovery on the part of the student. For the student, this means relinquishment of habits of passivity, docile learning, and dependence on teacher and textbook, in favor of an active learning in which lecture and textbook are challenged."

Unfortunately, the student is all too often faced with a gnawing feeling that the educational establishment gives inadequate preparation for his vocation whether it be brick layer or politician. This is a feeling that is expressed by those who persevere to graduation. We need not remind ourselves that some do not make it to graduation. "Approximately 29% of the nation's potential 'class of 65' withdrew from school between fifth grade and high school graduation," stated the May 1967 issue of the NEA Research Bulletin. Over half of those who start in college do not finish. Some blame the school of failing to stimulate the student. Whatever the reason, it can be easily recognized that one significant thing educators can do is to adopt the philosophy of simulation - that is, to think in terms of bridging the gap between theory and practice - between textbook learning and vocational performance.

The philosophy of simulation also implies that attention should be given to making the learner a participant <u>in</u> a realistic learning experience rather than an observer <u>of</u> a learning experience. Simulation represents in the educational sense a new and different experience for the learner. As stated above, teaching for the most part involves the presenting of information either through lecture or text. Yet, students desire new experiences. William Thomas (1951) states that this desire, or wish, represents one of four types of forces that impel the human to action. The excitement generated by a seal hunting expedition (cf., Abt, 1966) or an encounter with a simulated class (cf., Twelker, 1967) brings the student new experience that ordinarily would not be possible except through real-life encounters. The role of the student in a simulation experience is more that of a participant in the excitement that is generated rather than an observer of the excitement.

The philosophy of simulation also implies a unique opportunity to integrate the cognitive, affective, and psychomotor aspects of learning. Eli Bower[1] has pointed out that if one were to emphasize just the cognitive objectives in education, the result might be "an intellectual giant with no emotions". On the other hand, if one was to emphasize the affective domain, the result might be an "emotional explosion with no rationality". Educators are often prone to separate instructional objectives into neat categories (cf., Bloom, 1953; Krathwohl, et al., 1964), and often neglect to integrate what has been thought of as separate. Further, the emphasis on passive reception through lectures, textbooks, and the like, often leave little room for the activities that integrate the various types of objectives in a way that is meaningful. Simulation offers teachers, for example, an opportunity to deal with their emotions in handling the problems that demand the application of previously learned principles in classroom management and instruction. Valid educational principles might prove of little value if the teacher reacted in a negative emotional manner during a demanding occasion of decision-making.

It is interesting to note that browsing through a "pre-simulation" text on teaching (e.g., Mursell, 1954) brings to light some pedagogical "insights" that are as relevant today as they were 15 years ago. For example, "learning is meaningful in the proportion to which the situation or problem seems real or worthwhile to the learner, and in the proportion to which its essential interrelatedness is 'emphasized'." (Mursell, 1964, p. 39, 41-42). The problem with these principles, if indeed they be principles, is in the translation from theory to practice. How is learning made meaningful (relevant) to the student? How is the situation made real? Perhaps the philosophy of simulation can fulfill in part the requirements of Schwab and Fitzgerald, and bring the oft-quoted pedagogical principles that border on triteness into focus and utility. Perhaps the only price to pay is an open mind as the idea of simulation is pondered and practiced.

1 Personal communication

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