COMPUTER SIMULATION GAMES
Exemplars

by Ronald E. Anderson

The idea of using a "board" for parlor games stimulated the creation of hundreds of new games for serious learning as well as fun; likewise, the idea of using the computer for games has fostered the creation of hundreds of games, and we have only seen the beginning New technology, be it a board, dice, a computer printer, or a TV screen, not only provides a more lively structure for modifying old games but stimulates the evolution of entirely new forms of playing games. I certainly agree with Greenblat and Uretsky (1977) that "there is probably no single development that has had as significant an impact on simulation-gaming in the past century as the advent of the computer and the advances of this technology in recent years."

Pedagogical Contributions of Computerized Simulation

It is well known that computerized video games have conquered the arcades and filled every toy store. It is less well known that computerized simulation games have begun to offer remarkably new pedagogical innovations. The capacity to carry on "dialogues" provides the most dramatic new impact. Through person-computer conversations it is possible not only to simulate interpersonal interactions for educational purposes but also to replicate a tutor-student interaction. The computer program becomes a patient tutor which individually responds to each student depending upon his or her sequence of decisions. The two key features of electronic computers that give them conversational potential are feedback and the ability to display and process language. These skills, combined with large data storage, rapid computation, and control of input/output devices such as graphical display screens, open up vast new opportunities for simulation and gaming techniques.

Some of the inherent pedogogical advantages of computerized simulation games have been outlined by Roberts (1976) and others. In brief, they are:

1. Artificiality can be minimized by the introduction of many variables and complex systems.
2. Clerical work is reduced, allowing participants to concentrate on decisions more central to the basic goals.
3. Competition among students is reduced because they are typically playing against "nature" rather than against each other.
4. Computer games may be less threatening because the student is not performing for peers or for an instructor and hence feels freer to experiment and explore.

In summary, Roberts argues that computer simulation games eliminate some of the problems with "role-playing, board games" while increasing students' sense of control over their future:

> Games seem able to create this sense of efficacy by bringing real-world problems into the classroom and allowing the students the opportunities to practice making real-world decisions. The empirical research indicates a correlation between this sense of efficacy and school success.

Oregon

A good example of the compelling quality of computer simulation games is a program called *Oregon.* This game simulates a trip over the Oregon Trail from Missouri during the mid 1850s. The instructions are given in frame 1.1 and a sample run is listed in frame 1.2. The main challenge is to survive the full 2,000 miles by spending money wisely, by typing "hunt" words, and to a certain extent by chance. The simulation is designed for elementary and secondary history or social studies courses and is intended to give students a better idea for what the westward journey was like for the rugged individuals who attempted it.

Oregon appeals to students, who often play the game over and over. The program is accessed about 400 times a day on the MECC (Minnesota Educational Computing Consortium) statewide computer system, which makes it about 10 times more popular than any other computer simulation game or learning package on the system. The secret of its success in the marketplace is that students learn something about early American history while they are having fun.

Author's Note: The author wishes to express appreciation to Pete Trotter, Janet Frederick, Harold J. Peters, Dan Klasser, Alfred Bork, Catherine Dunnagan, and David Cook for comments on an earlier draft of this essay.

FRAME 1.1 Instructions for Playing OREGON

```
)LIB/OREGON
)RUN
DO YOU NEED INSTRUCTIONS  (YES/NO)? YES


THIS PROGRAM SIMULATES A TRIP OVER THE OREGON TRAIL FROM
INDEPENDENCE, MISSOURI TO OREGON CITY, OREGON IN 1847.
YOUR FAMILY OF FIVE WILL COVER THE 2040 MILE OREGON TRAIL
IN 5-6 MONTHS --- IF YOU MAKE IT ALIVE.

YOU HAD SAVED $900 TO SPEND FOR THE TRIP, AND YOU'VE JUST
   PAID $200 FOR A WAGON.
YOU WILL NEED TO SPEND THE REST OF YOUR MONEY ON THE
   FOLLOWING ITEMS

      OXEN - YOU CAN SPEND $200-$300 ON YOUR TEAM
             THE MORE YOU SPEND, THE FASTER YOU'LL GO
                BECAUSE YOU'LL HAVE BETTER ANIMALS

      FOOD - THE MORE YOU HAVE, THE LESS CHANCE THERE
                IS OF GETTING SICK

      AMMUNITION   $1 BUYS A BELT OF 50 BULLETS
             YOU WILL NEED BULLETS FOR ATTACKS BY ANIMALS
                AND BANDITS, AND FOR HUNTING FOOD

      CLOTHING   THIS IS ESPECIALLY IMPORTANT FOR THE COLD
             WEATHER YOU WILL ENCOUNTER WHEN CROSSING
             THE MOUNTAINS

      MISCELLANEOUS SUPPLIES - THIS INCLUDES MEDICINE AND
             OTHER THINGS YOU WILL NEED FOR SICKNESS
             AND EMERGENCY REPAIRS


YOU CAN SPEND ALL YOUR MONEY BEFORE YOU START YOUR TRIP -
OR YOU CAN SAVE SOME OF YOUR CASH TO SPEND AT FORTS ALONG
THE WAY WHEN YOU RUN LOW.  HOWEVER, ITEMS COST MORE AT
THE FORTS.  YOU CAN ALSO GO HUNTING ALONG THE WAY TO GET
MORE FOOD.
WHENEVER YOU HAVE TO USE YOUR TRUSTY RIFLE ALONG THE WAY,
YOU WILL BE TOLD TO TYPE IN A WORD (ONE THAT SOUNDS LIKE A
GUN SHOT).  THE FASTER YOU TYPE IN THAT WORD AND HIT THE
'RETURN' KEY, THE BETTER LUCK YOU'LL HAVE WITH YOUR GUN.

AT EACH TURN, ALL ITEMS ARE SHOWN IN DOLLAR AMOUNTS
EXCEPT BULLETS
WHEN ASKED TO ENTER MONEY AMOUNTS, DON'T USE A '$'.

GOOD LUCK!!!


HOW GOOD A SHOT ARE YOU WITH YOUR RIFLE?
  (1) ACE MARKSMAN,  (2) GOOD SHOT,  (3) FAIR TO MIDDLIN'
        (4) NEED MORE PRACTICE,  (5) SHAKY KNEES
ENTER ONE OF THE ABOVE -- THE BETTER YOU CLAIM YOU ARE, THE
FASTER YOU'LL HAVE TO BE WITH YOUR GUN TO BE SUCCESSFUL.
? 5
```


FRAME 1.2 Sample "Conversation" Playing OREGON

```
HOW MUCH DO YOU WANT TO SPEND ON YOUR OXEN TEAM ? 22
NOT ENOUGH
HOW MUCH DO YOU WANT TO SPEND ON YOUR OXEN TEAM ? 2222
TOO MUCH
HOW MUCH DO YOU WANT TO SPEND ON YOUR OXEN TEAM ? 222
HOW MUCH DO YOU WANT TO SPEND ON FOOD ? 333
HOW MUCH DO YOU WANT TO SPEND ON AMMUNITION ? 22
HOW MUCH DO YOU WANT TO SPEND ON CLOTHING ? 44
HOW MUCH DO YOU WANT TO SPEND ON MISCELLANEOUS SUPPLIES ? 55
AFTER ALL YOUR PURCHASES, YOU NOW HAVE  24  DOLLARS LEFT

MONDAY MARCH 29 1847

TOTAL MILEAGE IS 0
FOOD            BULLETS         CLOTHING        MISC. SUPP.     CASH
 333             1100            44              55              24
DO YOU WANT TO (1) HUNT, OR (2) CONTINUE
? 1
TYPE WHAM
? WHAM

RIGHT BETWEEN THE EYES---YOU GOT A BIG ONE!!!!
FULL BELLIES TONIGHT!
DO YOU WANT TO EAT (1) POORLY  (2) MODERATELY
OR (3) WELL ? 2
RIDERS AHEAD.  THEY LOOK HOSTILE
TACTICS
(1) RUN  (2) ATTACK  (3) CONTINUE  (4) CIRCLE WAGONS
? 3
RIDERS WERE HOSTILE---CHECK FOR LOSSES
WILD ANIMALS ATTACK!
TYPE BANG
? BANG

NICE SHOOTIN' PARDNER---THEY DIDN'T GET MUCH

MONDAY APRIL 12 1847

TOTAL MILEAGE IS 161
FOOD            BULLETS         CLOTHING        MISC. SUPP.     CASH
 371             939             44              40              24
DO YOU WANT TO (1) STOP AT THE NEXT FORT, (2) HUNT, OR (3) CONTINUE
? 1
ENTER WHAT YOU WISH TO SPEND ON THE FOLLOWING
FOOD? 0
AMMUNITION? 0
CLOTHING? 0
MISCELLANEOUS SUPPLIES? 3
DO YOU WANT TO EAT (1) POORLY  (2) MODERATELY
OR (3) WELL ? 2
LOSE YOUR WAY IN HEAVY FOG---TIME IS LOST

MONDAY APRIL 26 1847

TOTAL MILEAGE IS 302       -4-
```

Definitions and *Criteria*

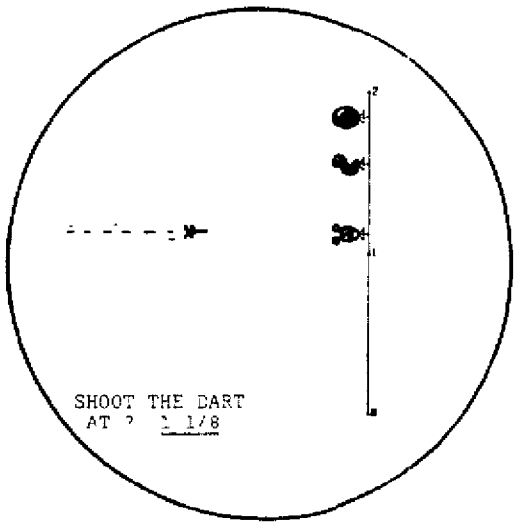
A word on definitions is in order before moving on to evaluation. Simulations and games in the computer context are evolving at an extremely rapid rate, and it is still too early to predict what forms will develop and become institutionalized. In the early days of computer simulation and gaming—that is, 5 to 10 years ago—simulation games were clearly identified as such. Now they may not be so labeled because they may be modules or components within a larger package of "courseware," the term for instructional packages. The Control Data Corporation PLATO system contains many such courseware units and illustrates the heterogeneity of simulations and games. Frame 2.1 shows a simulation game called *Dart* from the PCP mathematics material. The game is designed to assist in learning fractions. The student–player enters a fraction and then the computer program sends a dart flying across the screen at the place on the vertical scale. If it is the right fraction (or reasonably close) the dart will hit a balloon and burst it. *Dart* is an excellent example of computer-based animation and its possibilities for instructional design.

In Control Data's PLATO terminology, *Dart* is neither a simulation nor a game—it is simply a courseware unit. Although it simulates dart throwing, we would not call it a simulation because its intent is not to understand dart throwing; and while it can be played, some would not call it a game because if the player wins, nobody loses. Needless to say, much disparity exists over definitional boundaries for the terms *simulation, game,* and *simulation game.* The terms are evolving and it is impossible to predict how they will come to be defined.

Rather than take a precise, dogmatic position, I prefer a generous approach to definition. But since this discussion is an evaluative review, I am limiting myself to instructional simulation games. I have been open to and considered any simulation or game that has a computer component and is definitely instructional in character; these I call "computer simulation games."

Excluded from this review are noninstructional (or minimally instructional) games such as *Star Trek* (see, for example, Creative Computing [May-June 1975] pp. 40ff.), which resides on most computer systems. Also excluded from this review are problem-solving units that do not explicitly feature either a game or a simulation of a real-world process. Thus, I have not included such excellent instructional computer units as *Bertie* (available from CONDUIT), which teaches formal

FRAME 2.1 Display of DART Game on PLATO Screen



Note: the dart is flying toward the lower balloon and will burst it because the student typed in the correct answer of "1 1/8".

logic by checking student-entered deductions, because they are not clearly games or they do not contain an operating model of a naturally occurring process.

Still another exclusion is any program that solves problems by standard mathematical or statistical procedures alone. A simulation game may incorporate mathematical solutions, but most importantly it constitutes a process model that can be experimented with and is dynamic.

Finally, this *Guide* imposes further restrictions of scope. First, no simulation games are considered that are not advanced enough to be useful for high school students. The target audience is secondary and higher education. Second, I have excluded all business and management games because that area is reviewed separately.

In summary, I have restricted myself to evaluation of instructional computer simulation games, for practical purposes, which means I am interested in (1) any computer simulation of naturally occurring processes or (2) any game that directly depends upon the computer and, in either case, the simulation or game *must* be instructional and interactive in that students can experiment with the programs.

SOURCES OF COMPUTER SIMULATION GAMES

Using the criteria just discussed, the preparation for this review took me to numerous sources in search of any available computer simulation games. As mentioned earlier, I was not considering business games or those targeted below the secondary school level. Although I contacted many knowledgeable experts, searched computerized bibliographies (ERIC, for example), and consulted many published materials, the primary sources were:

Journals

- *Simulation and Games* (Sage Publications, 275 South Beverly Drive, Beverly Hills, CA 90212)
- *Creative Computing* (P.O. Box 789-M, Morristown, NJ 07960)
- *Pipeline* (CONDUIT, Box 388, Iowa City, Iowa 52240)
- *Journal of Experiential Simulation and Gaming* [formerly *Simulation/Gaming*] (Elsevier North-Holland, Inc., 52 Vanderbilt Ave., New York, NY 10017)

Proceedings of Annual Conferences

- "Conference on Computers in the Undergraduate Curricula" (CCUC/1, CCUC/2, ... , CCUC/9)
- North American Simulation and Gaming Association (NASAGA)

Computer Center Software Libraries

- MECC (Minnesota Educational Computing Consortium) 2520 Broadway Dr., Lauderdale, MN 55113. (MECC has been an acknowledged leader in instructional computing.)

Computer Company Software Inventories

- DEC (Digital Equipment Corporation, Maynard MA 0 754)
- HP (Hewlett-Packard, 11000 Wolfe Rd., Cupertino, CA 95014)
- CDC, Project PLATO (Control Data Corp., 8100 34th Ave. So, Bloomington, MN 55440)

These sources appear in order of current usefulness. That is, I found the journals most useful and the computer companies least useful.

For those interested in updating this article by reading the current literature, I recommend the following journals: *Pipeline, Simulation and Games,* and *Creative Computing. Pipeline* concentrates upon higher education, while *Creative Computing* is oriented more toward elementary and secondary education. *Simulation and Games* is mixed in emphasis and has a special section devoted to simulation reviews. While it is impossible to predict the publishing industry, these periodicals currently cover most of the developments in the field of simulations and games for computer-based instruction.

EVALUATION

When one attempts to select the "best," the "top 10," or even "exemplary" instructional simulation games, the overriding concern must necessarily be *quality.* Furthermore, the numerous dimensions of relevant quality such as validity, pedagogy, involvement, and so forth, must all be weighted and combined to arrive at an overall evaluation of quality. Thus my first question is what aspects or dimensions of quality are the most important.

Theorists and reviewers of simulation and games (cf. Boocock, 1972; Inbar and Stoll, 1972; Elder, 1973) emphasize such factors as validity, flexibility, impact, accuracy, plausibility, and so forth. These considerations generally concern either the substantive worth of the underlying model on the one hand or the user impact on the other. Quantitative assessment, however, with one exception (Anderson, 1976), has focused upon user or student ratings (cf. Dukes and Waller, 1976; Liggett, 1977). While user ratings are extremely important for measuring impact, many other considerations may be equally important] (Orbach, 1977). Substantive premises, clarity of documentation, and transferability of materials must also be taken into account.

CONDUIT has developed an evaluation scheme that attempts to take most relevant factors into consideration in reviewing computer simulation games and other instructional materials. They established a peer review system like that of professional journals and publishing houses. CONDUIT's goal is to assemble high-quality computer-based instructional units and deliver them to the educational community. Any computer simulation game of any merit within higher education is considered, but only the best are packaged and disseminated. A series editor in each of 11 disciplines coordinates the review procedure while a central staff performs any required technical modifications and manages the production of the packages. Anderson (1976) statistically analyzed the CONDUIT ratings of over 150 reviews of 80 packages, finding that five factors (dimensions) summarized the evaluation considerations. These five dimensions of quality are:

1. substantive pedagogy
2. presentation of concepts and theories
3. presentation of methods and techniques
4. student orientation
5. transfer expectancy.

Based upon these findings and upon less quantitative assessments, a slightly improved rating form was designed (see frame 3.1).

FRAME 3.1 CONDUIT Evaluation Rating Form

PART II:
EVALUATION

Column 1

Rate this package on each of the selected characteristics listed below by circling the appropriate number. Please complete this entire column before working on column 2.

Column 2:

Indicate the importance of each feature for this instructional package. Circle the appropriate number.

6 Exceptional
5 Very good
4 Good
3 Fair
2 Poor
1 Very Poor
A Item not applicable
B Insufficient information; can't evaluate
C Not qualified to evaluate

										Critical	Important	Optional	Inappropriate
A SUBSTANTIVE CONTENT													
6	5	4	3	2	1	A	B	C	1 Definition of key concepts	4	3	2	1
6	5	4	3	2	1	A	B	C	2 Discussion of underlying assumptions	4	3	2	1
6	5	4	3	2	1	A	B	C	3 Validity of principles, theories	4	3	2	1
6	5	4	3	2	1	A	B	C	4 Discussion of relevant literature	4	3	2	1
6	5	4	3	2	1	A	B	C	5. Overall substantive content quality	4	3	2	1
B DOCUMENTATION/TEXTUAL MATERIALS													
6	5	4	3	2	1	A	B	C	1 Clarity of information in textual materials	4	3	2	1
6	5	4	3	2	1	A	B	C	2. Completeness of instructor guides	4	3	2	1
6	5	4	3	2	1	A	B	C	3 Adequacy of instructions for operating programs	4	3	2	1
6	5	4	3	2	1	A	B	C	4 Overall quality of documentation	4	3	2	1
C SUPPORT OF THE TEACHING PROCESS													
6	5	4	3	2	1	A	B	C	1 Ease of integration with course procedures	4	3	2	1
6	5	4	3	2	1	A	B	C	2 Potential for improving instructor's ability to communicate principles and theories	4	3	2	1
6	5	4	3	2	1	A	B	C	3. Potential for improving instructor's ability to communicate methods and techniques	4	3	2	1
6	5	4	3	2	1	A	B	C	4. Potential for teaching how to interpret and apply results	4	3	2	1
6	5	4	3	2	1	A	B	C	5 Overall instructional quality	4	3	2	1
D STIMULATION OF STUDENT INTEREST													
6	5	4	3	2	1	A	B	C	1 Potential for capturing student interest	4	3	2	1
6	5	4	3	2	1	A	B	C	2 Challenge to student creativity	4	3	2	1
6	5	4	3	2	1	A	B	C	3 Student choice in patterns of use	4	3	2	1
6	5	4	3	2	1	A	B	C	4 Appropriateness for student-initiated work	4	3	2	1
6	5	4	3	2	1	A	B	C	5. Overall contribution to student motivation	4	3	2	1
E COMPUTER TECHNIQUES/MATERIALS													
6	5	4	3	2	1	A	B	C	1 Soundness of computer programming methods	4	3	2	1
6	5	4	3	2	1	A	B	C	2 Completeness of technical documentation	4	3	2	1
6	5	4	3	2	1	A	B	C	3. Portability (machine-independence of computer program)	4	3	2	1
6	5	4	3	2	1	A	B	C	4 Ease of program use	4	3	2	1
6	5	4	3	2	1	A	B	C	5 Overall quality of computer techniques	4	3	2	1
6	5	4	3	2	1	A	B	C	**OVERALL EVALUATION OF PACKAGE**	4	3	2	1

In the design and implementation of computer simulation games there are five major social roles, each with its own dominant orientations of quality. (The five sections of the CONDUIT form correspond to these five roles.) The roles are:

1. Scientist, scholar–oriented toward communication through materials
2. Author–oriented toward communication through written materials
3. Teacher–oriented to pedagogy
4. Student–oriented toward appeal, stimulation, and assistance in learning
5. Computer specialist–oriented toward interchangeability and integrity of computing techniques.

CONDUIT reviewers generally fill several roles; usually they are scientist/scholars, authors, and experienced teachers with some past experience with using computers in the teaching process. Such academically inclined persons will typically place a low value upon computer concerns. However, CONDUIT engages computer specialists to evaluate every candidate package and give their stamp of approval before the academics review it. This preliminary technical evaluation is simply to make sure that the transportability packaging will not be outrageously costly.

The final CONDUIT product must be quite high on all five standards. (1) substance, (2) communication, (3) pedagogy, (4) appeal, and (5) transferability. Like CONDUIT, I used the same five criteria to select a set of exemplary computer simulation games to highlight in this article. All the simulation games highlighted in the next section are reasonably high or satisfactory on all five standards.

EXEMPLARY COMPUTER SIMULATION GAMES

Figure 1 lists the computer simulation games selected as exemplary. This means that these game or simulation packages are outstanding as prototypes of what can be done instructionally with computer techniques. The selection does *not* mean that these are the most reputable or the very best 17 computer simulation games across all disciplines. In fact, one can note that, with one exception, no more than one package has been selected from any given discipline.

Some will be disappointed that no simulations were selected from such innovative projects as PLATO or PCDP (Physics Computer Development Project at the Irvine campus of the University of California). The latter project, under the direction of Alfred Bork, has pioneered the development of dialogue units that include simulations of processes that are graphically and dynamically displayed for each student. The problem with such packages is not their substantive or pedagogical quality but rather their poor transportability. Interactive graphics is not yet standardized within the computing field, and some of the display technology is still rather expensive. Because of the transferability problem, simulation games that use advanced graphical facilities are not listed among the exemplary packages, although they are included among the reviews in the section on computer games.

Some packages use graphical displays that can be made with a simple printing unit such as a teletype, which minimizes the transferability problem; *Limits*, which will be discussed later, and *Demographics* are cases in point. *Demographics* is not listed among the exemplary simulation games because it is first and foremost a data base query/analysis unit, the simulation component is quite minor.

SUMMARY DESCRIPTIONS

This section expands the brief phrases of Figure 1 into full paragraphs discussing each exemplary computer simulation game in turn.

Change Agent

The process of social diffusion of either information or innovation has long been of interest to social scientists interested in simulation. *Change Agent* embodies the generally accepted principles of social diffusion and turns the situation into a game in which the student tries to diffuse the innovation as quickly as possible. The scenario for the game is a rural village of 100 farms, and the student plays the role of a professional change agent who attempts to speed up the adoption of an important new farming method. *Change Agent* is appropriate for sociology and community courses as well as mass communication.

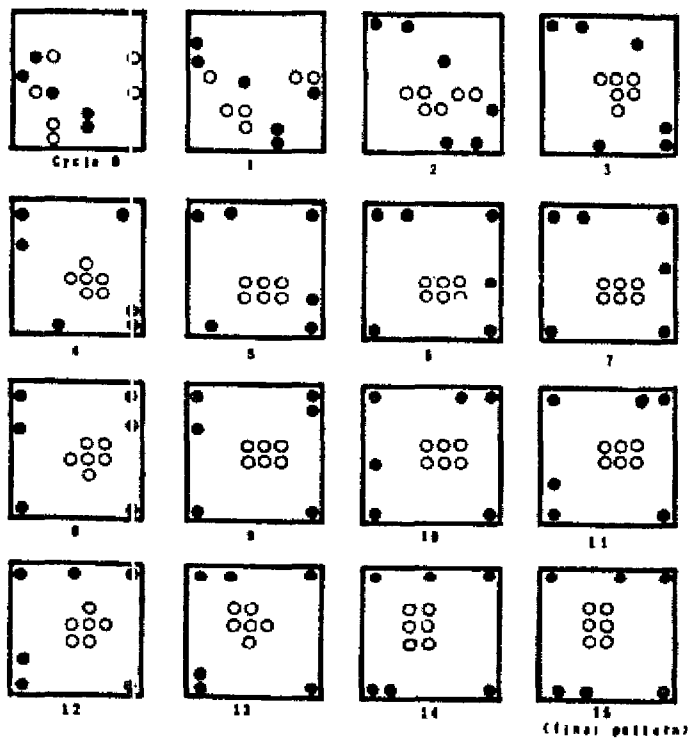
FIGURE 1 Summary and Subject of Exemplary Computer Simulation Games

Name of Package	Summary and Subject
Change Agent	social diffusion game experiments with adoption processes in a rural village (mass communication)
Chebo	social interaction simulation whereby actors move as a function of attitudes (social psychology)
Cognitive Psychology	series of laboratory exercises for cognitive or experimental psychology (psychology)
Critical Incidents	tutorial scenarios for training teachers in handling classroom incidents (education)
Energy (U.S. Policy)	policy analysis simulation of social, economic, and environmental impacts (policy)
EXPERSIM	generates data from any process model, e.g., model of a psychology experiment (psychology and other subjects)
Ghetto	revision of a board game to increase empathy with ghetto residents (urban culture)
IDGAME	game of minimizing costs in determining inorganic unknowns (chemistry)
INS2	group decision-making, role-playing game on international relations (political science)
INTERP	exercises for learning about the wave theory of light (physics)
Limits	exercises for speculating upon limits to growth due to system dynamics (economics)
Linkover	exercises with simulation of genetic mapping (biology)
Oregon	game of chance and typing skill for teaching American history at pre-college level (history)
Quantitative Experimental Analysis	simulations of different theoretical distributions demonstrating difficult concepts (statistics)
SIMSEARCH	tutorial exercises for decisions in designing social research (sociology)
Spatial Marketing	simulation and tutorials on locational analysis (geography)
Wheels	exercise in consumer decisions regarding automobile purchase and upkeep (home economics)

Chebo

Chebo, which stands for "checkerboard," is a model developed and programmed by Sakoda (1971) but described in Lehman (1978). *Chebo* operates a simple model of social interaction based upon some elementary principles of field theory and attitude/attraction theory. In brief, actors move closer or apart depending upon their current interpersonal distances, their attitudes toward members of their own group, and their attitudes toward members of another group. Such interaction is depicted in frame 4.1, in which one group, the social workers, is represented by open circles and the other group, lost souls, is represented by solid circles. At cycle 0, they are randomly dispersed around the checkerboard space, but by cycle 15, the final structure, the social workers are huddled in the center and the lost souls are spread around the outer boundary. This occurred largely because the initial starting conditions defined the social workers as having positive attitudes toward themselves as well as toward the outgroup, while the lost souls (solid) held negative attitudes both toward themselves and toward the outgroup. The model is included

FRAME 4.1 CHEBO Output Showing Interaction Between the Social Workers and the Lost Souls



because it demonstrates a variety of interesting social structures evolving from a very simple process.

Cognitive Psychology

Cognitive Psychology was written by Bewley for students in cognitive psychology or experimental psychology. It consists of a series of separate programs to simulate live experiments in each of these areas: pattern recognition, short-term memory, long-term memory, discrimination-net learning, concept learning, problem solving, and decision making in mixed-motive games. The package is modular, and an instructor can select a single simulation program for a specific laboratory exercise.

Critical Incidents

Critical Incidents (my name for "Simulated Incidents in Teaching") is for training teachers in handling human relations problems in the classroom. The underlying concepts and the terminology are based upon Transactional Analysis (TA), so some minimal reading or training in TA is required. The package provides 22 scenarios of classroom incidents and then asks the student (usually inservice teachers) how he or she would handle the incident. The program allows the teacher or teacher-to-be to try out various "theories" or solutions hypothetically, thus avoiding the emotional stress of a real-life situation. *Critical Incidents* is best described as a role-playing game rather than a simulation model. It is tutorial in format and the simulated events are determined by the implicit theories of TA.

Energy

Energy, which is short for *United States Energy, Environment and Economics Problem: A Public Policy,* simulates the economic and environmental impacts of specific policy decisions. The student inputs decisions on values and specifies alternative governmental structures. *Energy* is not highly interactive but is a good prototype of complex policy models. Interested instructors might consider *Policy* as an alternative. (*Policy* is a Huntington Two package available from Digital Equipment Corporation.) While *Policy* is narrower, it is more interactive and possibly more appealing to students.

Expersim

Expersim is listed as a psychology package, but it has much broader potential. It was originally designed for teaching research design and enables students to run simulated experiments with a computer module that generates the raw data they would have obtained had they performed the experiment in a laboratory. *Expersim* consists of a supervisor program, which manages specific user requests, and a collection of models or modules, which the supervisor program calls to generate appropriate data. Each model consists of several variables and specifies how these variables are interrelated. For example, the *Imprint* model contains variables such as "rearing conditions," type of imprinting target, age of bird, and specifies exactly how these factors work together to predict the strength of imprinting upon chicks. The program, of course, does not require the student to buy a supply of chicks. In addition to the imprinting model, *Expersim* has incorporated models for (1) the etiology of schizophrenia, (2) motivation in performing routine tasks, (3) effects of drugs on learning among rats, and (4) social facilitation effects upon performance. Other models from fields other than psychology have been developed, but their quality and availability are not yet well known.

Ghetto

Ghetto is a translation of the well-known board game into a computer game that one person can play. Some of the social and entertaining features of the board game are lost, so this is a controversial use of the computer. None the less, it is a prototype of what can be done with computerized versions of board games, and students have found it fun to take the roles of people living in a large urban ghetto. *Ghetto* is *not* designed for ghetto residents; rather it is designed to sensitize middle-class students to the social world of the ghetto. Someone has yet to design a game called *Middle Class* that would sensitize the children of the ghetto to the complex world of the middle class.

Idgame

In the field of chemistry, *Idgame* is a well-known and highly recommended computer simulation game for learning about organic qualitative analysis. Students run the program to generate simulated laboratory tests for the purpose of identifying unknowns. Students can run a number of simulated tests, but each test costs the student points. Thus the students compete with one another to minimize costs while obtaining enough data to be sure of the right answer. Other recommended simulation packages in chemistry include *Rkinet* and *Titration,* and both are available through CONDUIT. The PLATO system contains a novel simulation of titration processes (see frame 5.1) in which the addition of various chemicals can be graphically simulated; for instance, the density of the liquid in the bottle is visually represented by the degree of shading on the screen. Within chemistry there are many activities that lend themselves to instructional simulation games on the computer, and a number of new materials are likely to be available soon.

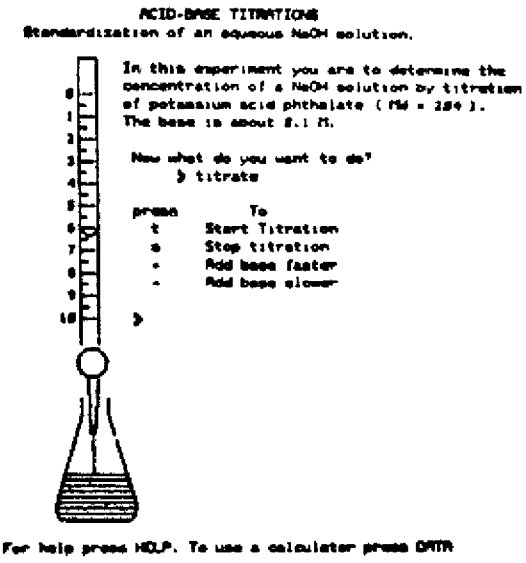
INS2

Inter-Nation Simulation, originally developed by Guetzkow, is a well-known role-playing game for a large number of participants. *INS2* is a new computerized version of this game, it includes (1) programs to aid the instructor in managing the game and (2) programs for the students to test the implications of their decisions before proceeding. Although the game requires a long time (four to eight one-hour sessions), it has established an important place for itself in the pedagogy of teaching international relations and policy decision making.

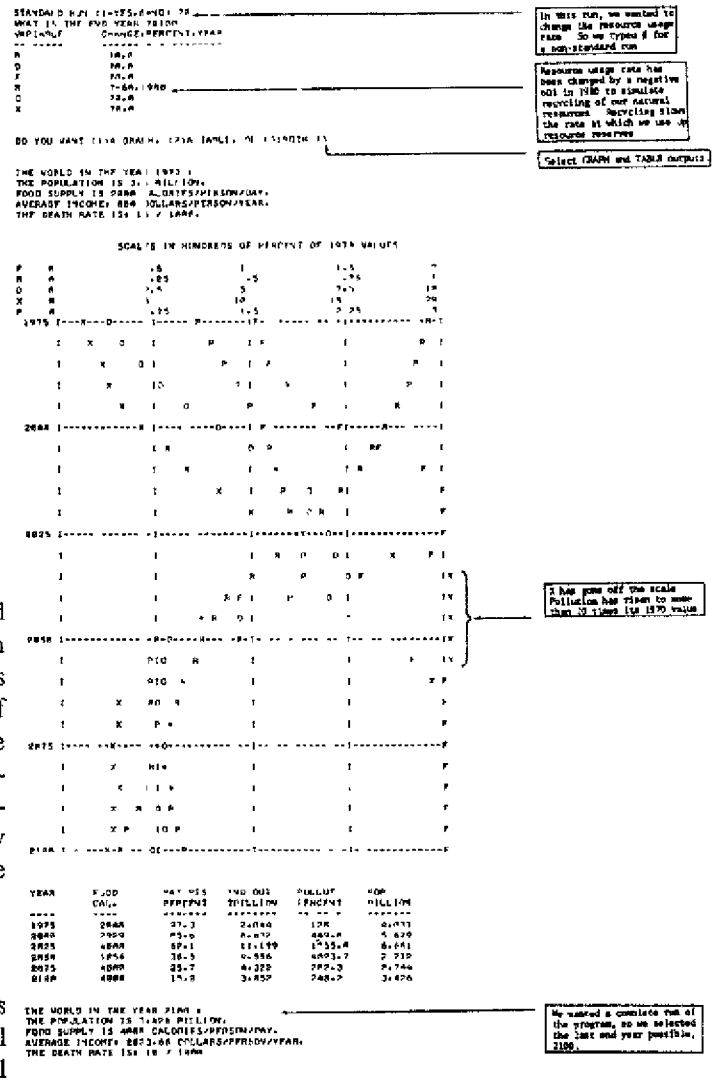
Interp

Interp has been chosen to represent physics, not for its elegance but for the appropriate simplicity of the model and

FRAME 5.1



FRAME 6.1 Sample Printout & Graph from LIMITS



thoroughness of the documentation. The unit was developed under the auspices of the Chelsea College science project in London, which has produced a number of other simulations as well. *Interp* is an aid to learning about the wave theory of light, specifically interference and diffraction phenomena. The model allows students to investigate the effects of the direction and distance of secondary source factors upon the intensity distribution. As already mentioned, there are the many less transportable physics packages available from the Irvine project.

Limits

Lunits is a Huntington Two simulation set up for students to get extrapolations of trends in population, industrial growth, resource consumption, pollution, and agricultural production. The simulation is a simplification of the Forrester-Meadows Limits-to-Growth model. Various input parameters can be adjusted and graphs of the implications printed out (see frame 6.1 for an example). The model, of course, is speculatory and controversial, but the simulation without a doubt helps to teach how variables interact in a complex system.

Linkover

Linkover is a biology package that simulates genetic mapping. Another interesting package from Chelsea College, it is designed to allow students to plan and execute a series of experiments to generate the data necessary to construct an accurate genetic map. Biology has a number of other good simulations including *Coexist, Ecological Modeling, Evolut, Compete,* and *Enzkin,* all of which are available from CONDUIT.

Oregon

Oregon has already been described. I would simply point out that because elementary and secondary students love to play *Oregon* so much, its pedagogical value is sometimes overlooked. A close reading of the documentation and the references cited will suggest a rich number of ways that the game can be integrated into the history classroom.

Quantitative Experimental Analysis

Quantitative Experimental Analysis provides a method of clarifying the difficult statistical concepts of estimation, distribution parameters, convergence, and power and significance. Most important, the unit is designed to demonstrate the connections between theoretical distributions and typical, empirical data. The programs simulate different theoretical distributions, some of which are known to the students and others of which are not known.

Simsearch

Simsearch, like *Critical Incidents,* is not based upon a formal simulation but provides hypothetical scenarios for sequential decision making. *Simsearch* poses problems of a sociological nature and then cycles the student through a number of decisions which allow him or her to construct a

full-scale research design. The package is particularly useful in demonstrating the hierarchical nature of design decisions, that is, the way decisions sequentially reduce the range of the remaining choices. It stresses both the importance of careful research planning and the close link between theory and method. The six design exercises deal with research problems in the areas of deviant behavior, family, sex-role socialization, sociology of sport, minority group relations, and the sociology of youth. *Simsearch* simulates research in each of these areas by making the student feel like someone who is managing a research project and constructing design plans.

Spatial Marketing

Spatial Marketing is a highly flexible simulation model that gives the student the ability to replicate the location of markets, the transportation system, the population distribution, and various economic and cultural parameters of a region. The strength of the package comes from the sophistication of the model, the thorough tutorial materials within the package, and the elegant displays of geographic phenomena. The package was developed by Ellinger (1977).

Wheels

Wheels, a simulation of automobile purchasing by a teenager, is the least academic of all the exemplary units. It is truly practical, however, in that it teaches about consumer decision making, including insurance, financing, and automative upkeep. Neither the manual nor the program requires a high level of sophistication or literacy. As a prototypical simulation game it suggests many ways that the computer could be used for mass, continuing education.

INTENDED AUDIENCE, COST, AND SOURCE

As already discussed and as shown in figure 2, most of the computer simulation games are targeted to the college or secondary/college audience. This probably results from the fact that computers have been in use at the college level longer than at lower educational levels. It may also be true that many simulations are easier to develop at the more advanced levels. In the next 10 years the situation will probably reverse itself as more and more units are developed at the secondary and elementary levels.

One disappointment is that simulation games written for the secondary level tend to be poorly documented and packaged. Developers seem to think that a program will be internally compelling and that others should figure out how to use it for themselves. One hopes that greater incentives will be found to support more complete documentation and interchange of programs.

DOCUMENTATION

Figure 3 gives for each simulation game the number of pages of student and teacher documentation. CONDUIT and others generally supply programmer notes with most packages to aid in the installation of programs. Teacher guides also sometimes contain programmer information. As one can see from scanning the right-hand column of Figure 3, most simulation game packages are self-contained in that they do not typically require specific articles or books.

Most of the packages have both a student and a teacher booklet or guide, and this is a very valuable practice. Sometimes the program can contain and print out documentation student users need, but usually students need more. Of course, there is the inevitable trade-off between fuller documentation and higher cost of materials for teacher and student alike.

IMPLEMENTATION CONSIDERATIONS

Even though the exemplary packages were selected to be relatively transferable from one computer to another, varia-

FIGURE 2 Intended Audience, Cost, and Source

Name	Intended Audience	Cost	Source
Change Agent	h.s.-college	$30.00	CONDUIT[1]
CHEBO	college-graduate	$15.00	James Sakoda[2]
Cognitive Psychology	college	$50.00	CONDUIT
Critical Incidents	teacher training	$60.00	CONDUIT
Energy (U.S. Policy)	college	$10.00	CONDUIT
EXPERSIM	college	$85.00	CONDUIT
Ghetto	h.s.-college	$50.00	CONDUIT
IDGAME	college	$65.00	CONDUIT
INS2	h.s.-college	$95.00	CONDUIT
INTERP	college	$25.00	CONDUIT
Limits	h.s.	$3.00	Digital Equipment Corp.[3]
Linkover	college	$20.00	CONDUIT
Oregon	h.s.	$15.00	Minnesota Educational Computing Consortium[4]
Quantitative Experimental Analysis	college	$90.00	CONDUIT
SIMSEARCH	college	—	CONDUIT
Spatial Marketing	college	$95.00	CONDUIT
Wheels	h.s.	$46.00	Paul S. Amidon and Associates[5]

1. CONDUIT, Box 388, Iowa City, Iowa 52240
2. James Sakoda, Department of Sociology, Brown University, Providence, RI 02912
3. Digital Equipment Corp., 146 Main Street, Maynard, MA 91754
4. Minnesota Educational Computing Consortium, 2510 Broadway Drive, Lauderdale, MN 55113
5. Paul S. Amidon and Associates, 1966 Benson Ave., St. Paul, MN 55116

FIGURE 3 Computer Simulation Games: Documentation

Name	Student Guide (pages)	Teacher Guide (pages)	Other
Change Agent	11	12	–
CHEBO	None	–	described in Lehman (1978)
Cognitive Psychology	102	96	–
Critical Incidents	10	30	ref. on Transactional Analysis
Energy (U.S. Policy)	52	–	–
EXPERSIM	under revision	under revision	
Ghetto	20	–	–
IDGAME	52	–	–
INS2	57	100	programmer's guide
INTERP	11	15	–
Limits	41	19	55 p. resource handbook
Linkover	11	15	–
Oregon	–	25	–
Quantitative Experimental Analysis	–		–
SIMSEARCH	–	?	–
Spatial Marketing	–	?	–
Wheels	23	–	–

FIGURE 4 Computer Simulation Games: Implementation Considerations

Name	Language	Lines of Program	Special Issues
Change Agent	BASIC	376	–
CHEBO	FORTRAN	about 800	listed in App. A of Lehman, 1977
Cognitive Psychology	BASIC	about 1,200	6 programs
Critical Incidents	BASIC	about 15,000	26 programs
Energy (U.S. Policy)	FORTRAN	605	batch program
EXPERSIM	FORTRAN	?	extremely large
Ghetto	BASIC	about 2,000	needs random access data files
IDGAME	FORTRAN	1,500	3 data files
INS2	BASIC	about 3,600	12 data files
INTERP	BASIC	284	–
Limits	BASIC	240	–
Linkover	BASIC	380	–
Oregon	BASIC	670	–
Quantitative Experimental Analysis	?	?	–
SIMSEARCH	BASIC	?	–
Spatial Marketing	BASIC	?	–
Wheels	BASIC	?	–

tions in computer systems make complete standardization impossible. Figure 4 gives some technical characteristics that are of interest to installers. Only four of the simulation games are written in the Fortran language; the remainder are in the Basic language. The number of lines of the program indicates size, not complexity. For instance, *Critical Incidents* has about 15,000 lines of program, but because the structure of the program consists almost entirely of branching and of printing tutorial text, the package is relatively easy to install, even on small computers, as long as programs can be chained and conveniently stored. (*Critical Incidents* consists of 26 separate programs, and these may have to be stored in separate files.) *Ghetto* is probably the least transferable package listed, due to its complex internal structure and its requirement for random access files.

These data on internal program characteristics are provided to give a sense of the variety of program issues. None of the issues in the exemplary package set is serious enough to be cause for rejection. If there is a need for any one of these units, chances are the effort to implement will be extremely minor. We would not make such a claim, however, for the typical package outside this highly select subset.

CONCLUSION

The many simulation and gaming possibilities opened up by the widespread availability of computers has generated a diverse collection of simulations and games. But with the exception of *INS2*, all of them contain at least one instructional unit that can be assigned as a single laboratory or homework exercise. Almost all of the computer simulation games can be played by a single student. So it would seem that computer technology is definitely having an individualizing impact upon instruction. For the most part this is desirable because more and better learning is possible. I anticipate, therefore, the development of many more such self-contained simulation game packages for both high school and college students.

I also predict another type of institutionalization of instructional simulation and gaming. Simulations and games will be built into large courses of instruction called *courseware*. In such cases students will probably be less aware of the underlying technical and pedagogical strategies. Thus one may become less aware of how he or she using simulations and games even though they are being used more. With this declining visibility of simulation and game units, the assessment of quality may become more difficult. The tendency will be to evaluate larger units or even entire computer-based courses. In such cases the individual simulation or game modules may not receive close scrutiny.

On the other hand, with the increasing institutionalization of computer simulation games in instructional design, the

methodologies will improve and expertise will expand. There should be many high quality, creative new developments with computer simulation games.

REFERENCES

Adams, Dennis M. 1973. *Simulation Games: An Approach to Learning.* Worthington, Ohio: C.A. Jones Publishing Company.

Anderson, Ronald E. 1976. Technical standards and performance standards in the pursuit of quality. *Behavioral Research Methods and Instrumentation* 8,2: 211-17.

Baker, Justine C. 1975. *The Computer in the School.* Bloomington, Ind.: Phi Delta Kappa Educational Foundation.

Boocock, Sarane S. 1972. Validity-testing of an inter-generational relations game. *Simulation and Games* 3,1: 29-40.

Boocock, Sarane S., and Schild, E.O. 1968. *Simulation Games in Learning.* Beverly Hills, Calif.. Sage.

Dukes, Richard L., and Waller, Suzan J. 1976. Validity-testing of an inter-generational relations game. *Simulation and Games* 7, 1: 75-96.

Elder, C.D. 1973. Problems in the structure and use of educational simulation. *Sociology of Education* 46 335-54.

Ellinger, Robert S. 1978. Spatial Marketing Simulation: A new package. *Pipeline* 3, 3: 26-31.

Greenblat, Cathy Stein, and Uretsky, Myron. 1977. "Simulation in social science." *American Behavioral Scientist* 20, 3: 411-26.

Inbar, Michael, and Stoll, Clarice, eds. 1972. *Simulation and Gaming in Social Science.* New York: Free Press.

Lehman, Richard S. 1977. *Computer Simulation and Modeling: An Introduction* Hillsdale, N.J.. Lawrence Erlbaum Associates.

Liggett, Helen. 1977. An evaluation instrument for use with urban simulation games. *Simulation and Games* 8, 2: 155-88.

Maidment, Robert, and Bronstein, Russell H. 1973. *Simulation Games: Design and Implementation.* Columbus, Ohio: Merrill.

Orback, Eliezer. 1977. Some theoretical considerations in the evaluation of instructional simulation games. *Simulation and Games* 8, 3 341-60.

Rawitsch, Dan. 1978. Oregon Trail. *Creative Computing* 4, 3: 132-39.

Roberts, Nancy. 1976. Simulation Gaming: A Critical Review. Eric Document No. ED 137 165.

Sakoda, James M. 1971. The Checkerboard Model of Social Interaction. *Journal of Mathematical Sociology* 1. 119-32.

Tansey, P.J. and Unwin, Derick. 1969. *Simulation and Gaming in Education.* London: Methuen.