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Introduction

Computer simulations have been utilized for well over twenty years as an instructional tool in business curriculums. According to Joseph Wolfe (1993), use of business computer simulations is no longer "cutting-edge." Simulation games have become common place with utilization widespread in the university community.

The reasons for implementing business computer simulations are varied but typically emphasize provision of decision-making experiences simulating the real world and role playing (Hsu 1989). Increased interest and utilization of computer simulations in the business curriculum arose after the general acceptance of experienced-based learning theory. Such experiential learning requires participants to be actively involved in learning situations.

Business simulations should serve as vehicles to provide experiential learning environments not to deliver knowledge according to Hsu (1989) in "Role-Event Gaming Simulation." The environment should be monitored and controlled by the game administrator.

One of the strengths of business simulations is the group orientation of the experiences. As group activities permeate most business decisions, the use of simulations to provide learning experiences is most appropriate. Business simulations provide opportunities for participants to acquire and practice skills in a realistic setting (Nowak & Adams 1988).

Business computer simulations have inherent weaknesses due to (1) time constraint within which the typical simulation is employed and (2) models generalize the system being portrayed. While both factors adversely impact the validity and relevancy of the gaming experiences, the time constraint may produce the most damaging results.

Time duration limitations may create an environment which facilitates short-run and excessive risk taking strategies (Mayo 1990). Evaluation of simulation activities may reward styles of decision-making which are inappropriate in the real world. Such evaluation schemes focus on achievement of bottom line results which typically sacrifice long term investments in the business for short term costs reductions. These experiences are at the opposite end of the spectrum with the reasons for using simulations. As a result, time duration limitations for the simulation may create an environment where participants learn inappropriate decision-making strategies.

Model building, in general, employs dominant characteristics of the system being represented. In this attempt to simplify or generalize the system, the number of variables is artificially restricted. Variables included in a business computer simulations determine its true potential to model the real world. As the number of variables increases, the complexity of the decision increases as well. This increase in complexity may or may not be desirable depending upon the objectives of the simulation. Therefore, designers must pay particular attention to the time constraints and variables employed in the business computer simulation.

To overcome the time limitation weakness of business simulations, a well-structured evaluation and feedback process must be a major component of the experience. This feedback process should emphasize knowledge and principles previously introduced to the participants via mechanisms external to the game environment. Such allows for positive reinforcement of appropriate decision-making strategies and constructive evaluation of inappropriate ones.

The second noted weakness of simulation concerning model complexity and number of variables must be addressed during design and development using measures of reality, validity, and relevance. Such measures are dependent upon the developer /author's business experiences.

The complexity of the simulation should reflect the activities required to support the learning objectives which the simulation was developed to meet. Despite weaknesses and limitations of simulations in the learning environment, simulations can provide enriched experiences for participants. According to Keys and Wolfe (1990), "Management games have been found to be generally effective and to possess internal validity in the strategic management type course."

Given the wide spread acceptance and use of business simulations, the authors decided to construct a simulation for use in a specific course to provide group decision-making experiences unavailable through other means or games. The objective of this article is to provide a conceptual framework for develping a computer simulation game that requires role playing by participants. Using experiences gained while developing a computer simulation game, the authors describe the model building process utilized to develop a pc based business simulation for use in upper-level, undergraduate management courses.

Steps in the Model Building Process

In order to develop a highly effective, discipline-specific, computer-assisted simulation, the authors have identified a six-phase, 11-step process as depicted in Figure 1 below. There is no simple process to develop a simulation. Development of a potentially successful simulation involves a number of complex and time-consuming steps which cannot be condensed.

Phase One: Developer/Author Objectives and Market Needs

The first phase of the model building process begins with the identification of a potential need for a new simulation package and making the commitment to go through the rigor, research, and testing

Figure 1. Discipline Specific Simulation Model Building

Establish Simulation Objectives:
- Understanding of Course Principles
- Applications Experience
- Enhanced Learning Experience
- "Bottom-Line" Alignment
- Improved Student Involvement
- Transferability of Material to "Real Life"

Determine Model Simulation Flows:
- Overall Experience
- Individual Session Experience
- Determine Critical Information Flows

Commit To Simulation Design Process

Market Analysis:
- Current Product Analysis
- Determine Need for New Product
- Analyze "Time-to-Market"
- Contract With Publisher

Determine Evaluation Criteria:
- Results Data Needed by Administrator
- Results Data Needed by Participants
- Form in Which Data is Transferred

Body of Discipline-Related Literature:
- Course Specific Materials
- Applications Knowledge
- Directional Analysis
- "Bottom-Line" Identification

Choose Computer Language:
- Build General Flow Model
  - Participant
  - Administrator
- Write Initial Code

Publish Completed Simulation

Write Support Material:
- Participants' Manual
- Administrator's Manual

Quality Testing:
- Debug Code
- Check Outcomes
- Test Ease of Use
- Test Consistency of Use

Feedback (Continual):
- Beta Tests
- Participant Surveys
- Administrator Surveys
- Focus Groups

Key
Phase One
Phase Two
Phase Three
Phase Four
Phase Five
Phase Six

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requirements that will be necessary if the final simulation is to fulfill the identified classroom need. There are three commons situations which lead to the developer/author(s) making this commitment.

These are: 1) the insight as to what will help make the classroom experience more effective for the student or participant; 2) the apparent lack of a suitable simulation already on the market; and 3) the desire to be helpful to the discipline in developing pedagogy that improves demonstration of the underlying concepts and learning objectives of a particular course.

Once the commitment has been made, however, then it is time to engage in the first step of the process which involves both the establishment of the simulation's objectives and a market analysis. Objectives which identify the core course principles that can be learned through the simulation will help the developer/author develop an clearer understanding about how the applications within the simulation will need to be constructed. Objectives should also include a solid "bottom line," or a specific statement about what the experience should lead to in terms of the students knowledge base and overall course effectiveness. They should also include a marked increase in student involvement within the subject matter and a "real world" applications outcome as well.

Developing these objectives while conducting the market analysis is often very instructive to the developer/author. Many publishers who are interested in such projects often have ready data available in terms of what presently is found on the market and what market surveys indicate in terms of the need for new products. Publishers often are also helpful in providing the developer/author with information regarding time-lines to help establish the new product in the market at the most opportune moment to capture trends and changes in discipline bases.

Now begins the process of actually writing the simulation. Information that has been generated in setting objectives and fitting a market need come together to help the developer/author determine how the simulation should flow (step 2). The developer/author needs to solidify what the overall simulation should be in terms of individual and group experiences, specific lessons to be learned, and how information and decisions should flow among participants and the simulation administrator. Here, not only are the initial objectives important to help make these determinations, but market data can also be helpful in allowing the developer/author to acquire a better sense of what experiences work better than others. Bringing in the initial literature review which supports these guidelines is appropriate at this time and also allows for an initial test of validity to the proposed structure of the simulation experience.

Phase Two: Establishing Structural Criteria

The next step involves translating the objectives of the simulation into specific results criteria which the experience will generate (step 3). These criteria then need to be combined with the simulation flow (step 4) and refined into definition of results from each individual simulation session, requirements of the participants, and requirements of the administrator. Some of these session results may be transferable between the participants and the administrator electronically, and will require specific interactive coding once the developer/author begins to design the software specifications. Other session results may be best transferable by written report, while still other session results may involve both written and electronic communication patterns between the participants and the administrator.

Resolving the communication patterns is of paramount importance to the developer/author in determining overall simulation objectives as well as data flows. A mix of media exchange between the participants and the administrator has proven to be more successful than trying to make all decisions either electronic or written, or written one-way and electronic the other. A mix provides a sense of reality within the simulation reflecting the variety of communication flows occurring in business.

Phase Three: Writing

With the simulation's flow determined and the evaluation material established, the developer/author can now move on to the actual writing portions of the simulation's development. There are four major activities involved in this phase: 1) writing of the code in computer language for the computerized portion of the simulation; 2) writing a manual or users' guide for the participant; 3) writing a manual or users' guide for the administrator to provide guidance for conducting the simulation; and 4) in-house quality testing.

Simulation development begins with writing code (step 5). Prototyping can be extremely beneficial during software development allowing different approaches to be evaluated for effectiveness.

Once data flows operate as intended and the program appears to be error-free, then the manuals can be written (step 6). Two manuals are required -- one for participants and a second for the administrator. The participant manual will contain a complete explanation of the objectives and operational methods of the simulation, as well as a detailed explanation of how data (electronic and written) is generated and input.

These manuals must be "user friendly" in that it is always an error for the developer/author to assume that the participants' skill levels will match those of the developer/author. In some cases, the participant may be computer illiterate or have minimal computer skills limited to common personal computer usages such as word processors or spreadsheets. The manual must be jargon-free and written in a style that allows for any qualified potential user to understand the objectives, methods, flows, in-put requirements, outcome reports and special features of the simulation experience.

The administrator's manual presents a different type of challenge. The administrator's manual must provide the administrator with enough information to allow this person to 1) easily run the simulation, 2) employ special features found in the simulation experience, 3) answer questions of participants, and, 4) fully understand the intent and logic of the simulation.

A rigorous quality testing plan must be established and utilized to ensure a simulation that works (step 7). The double arrows identified in this step of Figure 1 indicate that during this phase of development, quality testing must be a constant part of the process. At this point, in-house testing and quality checking can be done with focus groups or small groups of students who understand that the developer/author is working on preliminary program and written materials. Areas of concern include the quality of outcomes that actually result from simulation activity, the ease of use by both the participants and administrator, and the consistency of activity and outcomes from one session to another. Results of initial tests using

these methods will identify where errors occur and allow both rewriting of the program and the manuals to specifically address how the problems might be overcome.

Phase Four: Latter Internal Checks

Once phase three has been successfully completed with the operation of the simulation providing predictable results, it is advisable for the developer/author to verify that the original objectives, market analysis, and the body of discipline-related literature which have served as the foundation of the simulation founding criteria are met (step 8). During this phase, the developer/author can assure that the simulation matches the original philosophical and market objectives. Unless a significant effort is made to match outcomes to expectations at this point, much of the value and quality of the simulation will be in danger of being lost.

Phase Five: External Testing

The true quality of the simulation will begin to be evident once external beta testing begins. There are a variety of ways of conducting beta tests including using test sites located by the developer/author and sites located by the publisher, as two examples. Beta testing is a critical step in the process (step 9). Beta testing provides the developer/author with data from participants and administrators who have limited knowledge of the simulation's program and manuals. Results of the beta testing will show whether or not participants and administrators will be able to conduct the simulation without expert help.

It is advisable for the beta test participants to complete a detailed, focused survey concerning all aspects of the simulation. It may well be that further refinement of both the program and the manuals will be necessary at this point (step 10), and to some degree, the developer/author may need to return to steps 6 and 7 when major changes lead to significant alterations in the flows and outcomes of the revised product.

Phase Six: Publication

Only when the publisher is assured that the foundation objectives of the simulation have been met and that the computerized portion of the simulation has been sufficiently de-bugged, will a publication date be set (step 11). At that point, the developer/author's work is essentially done, and the publisher's production and marketing departments proceed.

Experiences and Lessons Learned

Several versions of the simulation evolved during the several year development process. Participants were observed and monitored to determine changes and modifications in the rules of the game and the computer interfaces. Participants were asked for feedback on simulation activities to guide development

of the prototypes. The most significant results of the observations are reported here to facilitate future design of computer business simulations.

The first prototype was designed to assess group behavior and communication flows with limited interaction with the computer. Initially, only one company manager/officer was to enter the decision. Observations of the communication flows within individual company groups revealed that with this scenario only the manager/officer involved with the computer actually made the decisions. Other participants perceived they had "nothing" to do! Therefore, this prototype was quickly scrapped. All remaining versions required all participants to interact with the computer via menu driven options and prompts.

Participants were quick to perceive patterns and relationships of decision variables and outcomes. Variables and algorithms were changed after several iterations of the prototype due to observed inappropriate behaviors of the participants. Some examples of included: impact of advertising and marketing expenditures, investment opportunities for "excess" cash, price elasticity of products, and payback in the short-term for expenditures on product research and development.

Objectives of the simulation included corporate responsible behavior and ethical behavior of the participants. This behavior did not appear unless the algorithms rewarded. Thus, even though the administrator evaluated the participants in a global fashion, the participants were guided by the profit/loss statement and market share.

Modifications were made to the participants' manual. Even though decision-making under conditions of ambiguity is considered a skill set for managers (Hsu 1989), participants discomfort with ambiguity led to distractions from the original objectives of the simulation for learning environment. Therefore, more information was added to structure the decision analysis performed by the participants.

Finally, quality testing led to changes in the software recognizing different pc configurations including disk identification, printer types, and the like. Testing for all possible incorrect entries including type, ranges, and miscellaneous rogue entries was performed. It is recommended that both black box and glass box testing strategies be employed.

Conclusions

Simulations can be extremely useful in applications where experiential activities reinforce concepts and principles of specific topics. Simulations should not be expected to deliver information rather simulations should provide realistic environments where decision-making strategies may be applied and tried by the participants.

Designing a computer simulation for management courses requires a great deal of effort and commitment to the project. The process requires determination of objectives, designing the structural criteria, writing, and multiple phases of quality testing both internal and external. Prototyping with intensive feedback and observation of the participants is a useful design method for developing an effective simulation game.   The final publication phase can be attempted only after successful

completion of the previous five phases. The multiple phases of quality testing are critical to the success of the project.

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