INVENTORY SIMULATION
A Time-Sharing Television Output Simulation

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Nearly every business school today makes some use of simulation in its curriculum. The typical format is to offer a simulation game as part of another course, such as Introduction to Business or Business Policy, and the students play one game for the entire term. Decisions are usually made during one class period and submitted at the end of the period for umpiring. The decisions are then processed on a batch computer and the results returned to the students the next class period, anywhere from a day to a week later, when another set of decisions is made.

This unfortunate time lag between decisions and results is hardly in keeping with the proven learning concept of quick reinforcement, and some years ago we began experimenting with using a time-sharing computer as the vehicle for umpiring simulation games. The enthusiastic support given by the students to the quick feedback approach led to the development of a complete set of time-sharing games that permit offering a full course in management simulation. These games have recently been published by Reston Publishing Company (FRAZER -BUSINESS DECISION SIMULATION - A Time-Sharing Approach) and are thoroughly documented and tested, with a complete and detailed instructor's manual and program tapes available to adopters.

The full course in management simulation using timesharing as the format has several advantages over simulation in the normal format.

I. Results of decisions are returned in just a few minutes after decisions are submitted, thereby enhancing the involvement of the participants and reinforcing the learning experience by giving the results while the decisions are still firmly in mind. Games are played from start to finish in one two-hour period, thereby further enhancing the involvement through experiencing the entire game from opening discussions to final results at one time.

2. Students are exposed to a wide variety of games ranging from quite simple to fairly complex. Thus more students get involved early in the course and get a grip on the gaming procedure before being challenged by more complex games. The playing of multiple games makes it possible to cover a wide variety of different situations calling for

various sorts of analysis. Each game covers one or more of the elements of strategy, negotiation, and management science, and the students have an opportunity to apply techniques learned in many different courses.

3. Students are grouped on different teams for each game. Thus, each game provides a new experience in small group behavior as teams endeavor to come up with a common decision that is acceptable to the entire team. Leaders evolve on the teams in a variety of ways; through the makeup of the team, the preparation put into analysis of the game by individuals on the team, and the reputation team members have established in previous games. The leadership struggles that take place at the beginning of each game are a part of the simulation experience that may be just as valuable as the analysis of the games, and the full effect can only be secured through the playing of many different games.

The multiple game, multiple team, quick feedback of re- suits format of this innovation vastly increases the amount, the variety and the quality of the simulation experience. The caliber of the experience is best attested by the comments of the students in evaluations made at the end of the course. Some typical comments--all taken from those made by part-time evening graduate students--follow:

"Tremendously enjoyable, requires thinking logically, thinking critically, and testing the results of your thought processes •"

"The course was one of the most enjoyable I've ever had. It was fun and one of the reasons for this was that it allowed you to become totally involved in each class."

"The course gave me experience in group dynamics. It sharpened my logical, reasoning and persuasive skills."

"If Management Simulation II were offered, I would elect it without hesitation."

"Not only was it a truly learning experience but also the games were fun to play. The games were very representative of real world situations.''

"I feel I learned a great deal about small group dynamics and about how I react in such situations."

"Most interesting and rewarding. It does emphasize the Operations Research/Management Science approaches for use in 'real life' situations, i.e., Statistics and Modeling Concepts.''

"Meaningful learning experience. Very worthwhile; interesting."

,‘A very good course in human relations as well as developing managerial skills related to the games.”

“I can honestly say that I have enjoyed this course more than any other I have taken. This feeling is based on both the atmosphere and the concepts that come from playing the games.”

It is significant to note that some students perceive the course as one in human relations, while others comment on the analysis required for the different games. The course actually does blend the two major facets of management education-- behavioral management and quantitative analysis--very well, and may achieve this blending where nearly all other forms of management education fail.

We have looked upon the simulation course as a laboratory in management wherein the student is provided with an opportunity to apply some of the tools he has acquired in other courses. If he has not acquired the necessary tools elsewhere, it provides him with an opportunity to learn what some of the tools are that he is missing--often from others on his team that have acquired the tool--and thus provides a motivating force for learning when he later takes the appropriate course. As a result, we do not coach the students in what good decisions are, nor preach to them about what they should have done if they were not aware of the appropriate tool of analysis. Thus in the game where a knowledge of linear programming would be most helpful in preparing for the game, some groups may not have any background in linear programming and only be able to make seat-of-the-pants analyses, turning in decisions accordingly. After the game, a typical question might be “Isn’t there some easier way to make this decision?” A simple reply that linear programming provides the answer will often lead students to enroll in the linear programming course who otherwise would not do so.

Each of the game writeups represents a short, concise statement of the problem without any mention of the solution technique that may be appropriate. All information about the problem is given, however, and the student is not required to draw inferences about the nature of the distributions that pertain to the problem or the cost structure of the problem itself. Thus in the inventory simulation game no mention is made of such things as decision rules, economic order quantity, safety stock or order point analysis, but the writeup does contain a complete description of the nature of the distributions from which the demand is derived, the length of the lead time, and a listing of the pertinent costs, as well as a set of sample calculations that show how each of the values enter into the calculation of results.

The complete listing for INVENTORY SIMULATION taken directly from

FRAZER - BUSINESS DECISION SIMULATION is reproduced here.

INVENTORY SIMULATION

In this simulation, you are in charge of maintaining an inventory of a product that costs $10 per unit. The object of the simulation is to keep the cost of maintaining the inventory to a minimum.

Demand for the product averages 200 per week, based on an average of four customer demands per week, with each customer demand being for an average of 50 units.

The number of customer demands is randomly generated from a Poisson distribution with mean = ^{1}-i. The effective range is from 0 to 15 with approximately one chance in 100 that there will be more than 9 customer demands.

The size of each customer demand is randomly generated from a normal distribution with mean = 50 and standard deviation = 10.

At the end of each week you are given an opportunity to place an order to replenish your supply. When an order is placed there is a four week period until the order is received. Thus an order placed at the end of week 2 will arrive in time to be used in week 7.

There are three costs involved in maintaining the inventory.

One of these is the cost of carrying items in inventory, including such costs as the physical cost of storing, interest on the investment and risk of obsolescence. A charge of 26% a year is levied for these items, and is charged at $.05 per unit in inventory at the end of each week ($10 x .26/52 = $.05).

The second cost is the cost of placing replenishment orders. This cost is charged as $50 per order placed and is not affected by the size of the order.

The third cost is the cost of stocking out. This consists of both the cost of customer dissatisfaction and the profit foregone by failure to make a sale. The cost will be charged at the rate of $50 for each customer demand not completely satisfied plus $2 per unit not sold. Thus if we have L~O units in inventory when a customer demand for 50 units occurs, the stockout cost will be $50 + $2(50 - L~O) = $70.

A typical game will last for 52 weeks, with no ordering taking place during the last four weeks as the orders would not arrive in time to be used. Although teams are in

competition with one another, there is no interaction between teams and there may be anywhere from two to six teams competing at one time. Each team fairly quickly reaches a position different from the other teams and no secrecy about decisions is needed. Thus no decision forms are needed with teams merely calling out a decision to the operator of the computer terminal when they want to place an order.

Each team begins play with an inventory of 2000. The winning team will be the team with the lowest total cost at the end of play. Good luck.

Sample Calculations for Inventory Simulation

WEEK	DEM	INV	ON ORD	ORDER	CC	OC	SOC	TCST
0		2000						
1	300	1700	0	0	85	0	0	85
2	200	1500	500	500	160	50	0	210
3	20	1480	500	0	234	50	0	284
4	180	1300	500	0	299	50	0	349
5	260	1040	500	0	351	50	0	401
6	220	820	500	0	392	50	0	442
7	200	1120	0	0	448	50	0	498
8	120	1000	0	0	498	50	0	548
9	240	760	1000	1000	536	100	0	636
10	0	760	1000	0	574	100	0	674
11	300	460	1000	0	597	100	0	697
12	260	200	2200	1200	607	150	0	757
13	280	0	2200	0	607	150	260*	1017
14	120	880	1200	0	651	150	260	1061

*The stockout cost shown assumes five customer demands were received in week 13 with the size of each demand in order being 65, 45, 60, 45, 65. Thus 15 units for customer 4 and 65 units for customer 5 were not supplied, giving a stockout cost of 2 x $50 + 80 x $2 = $260.

The current values for the week as shown above will be given you each week for each team, except for the column labeled ORDER. You must keep track of the week you ordered to know when an order will be coming in.

The Inventory Simulation game is one of the fastest moving of the games and the 49 decision making opportunities is more than most games can provide. While the game can be played on an ordinary teletype with the results posted on the board, it is at its best when used with a display terminal that permits the class to see the results as they are generated by the computer. We use a Digi-Log Model 33 purchased from Digi-Log

Systems, Inc. for $1,295 and hook it up to a small monitor for the operator's use and drive a large TV monitor for the class to see. The game usually generates a lot of excitement and interest, with some surprising results for those not well versed in the intricacies of inventory models.

It is difficult to say who gets the most out of playing the game, one well versed in inventory models or a neophyte who knows nothing about inventory concepts. In truth, they both can learn from playing the game, although they learn different things due to the different level of understanding they bring to the game in the first place. The only important thing, if the competitive atmosphere that contributes so much to the learning process is to be retained, is to avoid having competition between groups of widely divergent abilities.

The game does provide virtually an ideal combination of analysis and pure luck in that poor play will almost certainly lose the game to reasonably good play, but the random factors are such that optimal play will not necessarily beat reasonably good play in any one game as the time period covered is too short. Thus, much as in real life, everyone who develops some feel for the game has a chance to win, whereas those who do not develop a feel for the relationships are virtually certain to lose.

The game itself will be presented at a demonstration to be held later in this meeting and you are urged to spend some time analyzing what strategy you feel to be appropriate and come and try your luck at the demonstration.