ENHANCING STUDENT LEARNING OF SIMULATION AND DECISION THEORY WITH MICROSOFT EXCEL AND VISUAL BASIC

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ABSTRACT

We describe a Microsoft Excel spreadsheet with a built-in visual basic macro to simulate the 3-Door Game Show ("Monty Hall") Problem. The macro is simple to use and provides a visual representation that piques students' interest in the problem and its solution. Students then create their own simulation model of the game show, which provides important insights into the problem and into simulation and decision analysis methods that can be used to solve it.

INTRODUCTION

Simulation and decision theory are consistently ranked as two of the most important analysis techniques that business students can acquire in their management science/operations research (MS/OR) courses [2] [4]. Despite their importance, [2] showed that only about half of the instructors surveyed covered the topics, and those who did so generally did not spend significant time on them. The low coverage of these two important topics may be due to the constraints of less course exposure time in MS/OR courses and additional software requirements for students [3] [5]. In this paper we describe a way to increase the coverage of both important topics under these constraints using an Excel Visual Basic for Applications (VBA) model. Because it is an Excel model, students are not required to purchase additional software or text material.

The example we use is the classic Monty Hall problem from the popular "Let's make a deal" 1970's television game show. We use the wording of the problem given in *Parade Magazine*'s "Ask Marilyn" column [8].

> *Suppose you're on a game show and you're given a choice of three doors. Behind one door is a car; behind the others, goats. You pick a door--say, No. 1--and the host, who knows what's behind the doors, opens another door--say, No. 3--which has a goat. He then says to you, "Do you want to pick door No. 2?" Is it to your advantage to switch your choice?*

It is assumed that the host knows where the car is, and will never reveal either the car or the contestant's first choice until after the contestant has decided to stay with her original choice or switch to the remaining door. Although it is to the contestant's advantage to switch away from her original choice (giving a 2/3 probability of winning), most students (indeed, most of the population) conclude that there is no advantage to switching, believing that the probability of winning in either case is 1/2.

Vazsonyi [7] indicated that many business school instructors have used this problem as an introduction to decision theory. Since the problem is so counter-intuitive, however, many find it frustrating to see "anchored" students who are never fully convinced by the result of the decision theory approach [6]. In fact, professors from prestigious universities and institutes have stumbled over the problem at first [8] [9] (see Appendix 1 available at http://home.business.utah.edu/mgtdgw/gameshow/Appendices.pdf). Therefore, the nature of the problem makes it an ideal example for students to visualize and solve using a spreadsheet simulation approach. Based on the insight they find during the course of constructing their simulation models, students convince themselves of the validity of the decision theory approach.

We note that others have suggested simulating the game show problem as a way to convince students of the answer (see [10] for example). What is different in our approach is that we are asking students to build the simulation model themselves. The insights that come from building the model lead to greater understanding than those that come from merely observing the results.

GAME MODEL DESCRIPTION

Using Excel's VBA module, we created the file "Lets Make a Deal Game.xls" to let students virtually participate in the game. We conducted this game in two sections of a required data analysis and decision making course for our Professional MBA (PMBA) program. Each section had about 78 students, whom we divided into 30 groups. Before playing the game, we presented the Monty Hall problem to groups and asked their decisions on whether to switch or not. Only 37.1% and 25.0% of the groups in the two sections chose the switching strategy. We then instructed students to play the game by clicking the "Play Game" button. (Screen shots of the different steps of the simulation can be found at http://home.business.utah.edu/ mgtdgw/gameshow/gamescreenshots.pdf.) Students can play as many times as they want and Excel keeps track of how many times they win using the two strategies. After several games a vast majority of students are convinced that the switch strategy is the better choice (80.6% and 94.1% of the groups in our two sections), but still some "anchored" students may conclude that the Excel program is rigged.

Nevertheless, at this point they are all eager to know what the exact probabilities of both the switch and no-switch strategies are, but they are usually tired of clicking the buttons. Thus, instructors can click the "Strategy Simulation" button available in the instructor version of the simulation game and choose a large number of simulation iterations, say 10,000 times. The record table shows that the chance of winning by choosing a switch strategy is about 2/3 while that of the no-switch strategy is 1/3. From our experience, at this stage students are all convinced and want to open the black box of this "Strategy Simulation" button to know how to use the spreadsheet to simulate this problem. It opens an excellent opportunity for instructors to introduce spreadsheet simulation.

SPREADSHEET SIMULATION MODEL DESCRIPTION

Before students can simulate the problem, we first introduce to students a 9-step simulation procedure, shown in Appendix 2 at http://home.business.utah.edu/mgtdgw/gameshow/Appendices.pdf. We then proceed to have students construct models similar to those in the "Let's Make a Deal Simulation.xls" file. The simulation file has four worksheets. In the first two worksheets we explicitly show the random numbers generated by Excel. The first worksheet simulates the no-switch strategy and the second worksheet simulates the switch strategy. The only difference between the first two and the last two worksheets is that we embed the "RAND" function inside other functions in the last two worksheets to make them cleaner. The last screen shot found at http://home.business.utah.edu/mgtdgw/

gameshow/gamescreenshots.pdf shows the 4th worksheet to illustrate the layout of the simulation.

Due to space limitations, the worksheets are described in more detail in Appendix 3 at http://home.business.utah.edu/mgtdgw/gameshow/Appendices.pdf. We use common simulation functions such as the VLOOKUP function (see [1] for example) to construct the worksheets, except for one trick that is worth mentioning here. The trick is used to specify the remaining door number after the contestant chooses one door and the host opens another. Interestingly, because the sum of the three door numbers is six, an easy way to specify the remaining door is to use six minus the sum of the two door numbers chosen by the contestant and the host. For example, a sample formula might be "=6-C10-D10," where C10 has the contestant's choice and D10 has the host's.

While building the simulation, most students come to the realization that once the contestant decides what strategy to use and makes her first pick, the result of the game is determined already. If the contestant uses a no-switch strategy, the chance of winning is equal to the chance that she selected the correct door on her first pick, which is 1/3. If using a switch strategy, the chance of winning is equal to the chance that she made a wrong first pick and then switches, which is equal to 2/3.

In addition, modeling the situation with the simulation shows the students that there are many instances in which the host has no choice of which door to reveal. For example, if the car is behind door 2, and the contestant selects door 1, then the host has to reveal what is behind door 3. Hence the host's choice is not completely random and is conveying information to the contestant. A realization of the information conveyance on the part of the host leads into a discussion of the role that new information plays in probability revisions in Bayes theorem. The simulation results combined with a Bayesian revision exercise lead into a natural discussion of the value of new information when making decisions. Therefore, the example serves as a very nice introduction to the concepts (and even some details) of decision analysis.

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