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The Use of Decision Support Systems (DSS) and Operations Research/Management Science (OR/MS) Techniques to Enhance the Learning Experience of Students Participating in Computerized Simulations

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ABSTRACT

Management games and simulations are now a commonly accepted pedagogy in most business schools. Despite their widespread use and acceptance, questions remain as to their effectiveness as teaching instruments. Two particular concerns frequently raised are: 1) the lack of adequate time to make reasonable business decisions between decision-making periods and, 2) the failure of games to draw upon and integrate various concepts and techniques--particularly quantitative techniques--students have learned in business courses. Because games are said to have these two shortcomings, critics charge that students often resort to 'seat-of-the-pants' decision making, thus washing out or abrogating the game's rationale--to help students in using and understanding the interrelatedness of business variables.

This paper focuses on one way the authors have utilized to overcome these shortcomings in order to provide the students with a more meaningful way to learn from management games. This paper demonstrates how learning can be facilitated in both 'general-purpose' and 'specialized' management simulations through the use of DSS. For the "typical" management simulation, the DECIDE simulation game was used. For the "specialized" simulation, DECIDE-P/OM (designed for Production and Operations Management Courses) was employed. Participants included both students and business professionals. Spreadsheet analysis, implemented with VISICALC, was used by participants as a DSS to enable them to model the effects of various decision scenarios on their own firm's profits prior to implementing their decisions. Although VISICALC was used in this study, the spreadsheet analysis which was performed could easily have been done using any of the other spreadsheet programs (such as Multiplan or Lotus 1-2-3)

INTRODUCTION

In 1956, the American Management Association developed the first business simulation, Top Management Decision Simulation [Taylor and Walford, 1972, 16). The participants acted as executives, made decisions, and saw the outcomes of these decisions. Since that time, simulations have been widely used in business and industry as part of company training programs. Business simulations have been cited as having a host of positive benefits [Conrad & Hedin, 1978; McKenney, 1962; Milton, 1978; Olivas & Newstrom, 1981] Even more widespread, however, has been the proliferation and use of management and business simulations--particularly computerized games--in business schools throughout the United States [Shay. 1980, 26].

This proliferation and use has been supported and encouraged by: game creators; business school faculties; AACSB guidelines requiring use of computers and Management Information Systems in the common core [AACSB Guidelines, 1984]; as well as an organization whose purpose is dedicated to the investigation--and it would seem, encouragement--of management games and simulation, (i.e., ABSEL). Despite this growing usage questions continue to be raised concerning the pedagogical value of these games and simulations. In particular, questions, concerns, and complaints have been raised by critics regarding the effectiveness and value of computerized games which typically require students to maximize a firm's profitability or stock market value by manipulating several variables at once over the simulated life of the firm. Rather than discuss in detail all of these questions, concerns and complaints, a summary has been prepared.

CONCERNS/COMPLAINTS	SOURCE (AUTHOR, YEAR, PAGE)
--students have false sense of knowing more than they really do	Ruben, 1982, 233. Cook, 1981, 4.
--not geared toward presenting new knowledge or material	Cook, 1981 4. Olivas & Newstrom, 1981, 63.
--large group make learning impractical	Olivas & Newstrom, 1981, 63. Jones, et. al., 1979, 128. Levit, 1971, 64.
--domination by one autocratic leader	Olivas & Newstrom, 1981, 63.
--requires, but can no guarantee involvement	Jones, et. al., 1979, 128.
--competition overemphasized	Kozma, et. al., 1978, 258. Catalanello, 1968, 4.
--oversimplification of reality	Kozma, et. al., 1978, 258. Jones, et. al., 1979, 128.
--decisions don't really count	Kozma, et. al., 1978, 258.
--takes too long to play	Shay, 1980, 27.
--overly complex	Shay, 1980, 27.
--too much out of class contact required	Crino, et. al., 1978, 169 Markulis, 1983, 1.
--increases student frustration	Lill, 1980: Wolf, 1976. Hand & Sims, 1975.
--failure to integrate	Olivas & Newstrom, 1981, 59.
--knowledge acquisition and knowledge retention are doubtful	

This paper addresses some of the major concerns and complaints raised by critics regarding the usefulness and value of management simulations. In particular, this paper describes how appreciation for and integration of business concepts can be enhanced using a variety of Decision Support Systems (DSS) and Operations Research/Management Science (OR/Mg) techniques. Further, it shows how such techniques can also be used to mitigate the time constraints characteristic of most games, and to lessen the degree to which 'seat-of-the-pants' decisions are made.

Before continuing, however, it is necessary to define DSS and OR/MS. DSS refers as much to a point-of-view relative to the role of computers as aids to decision making, as it does to a body of knowledge or discipline per se. Basically, DSS implies the use of computers to: 1) assist managers in their decision processes for semistructured tasks; 2) support, rather than replace managerial judgment; and 3) improve the effectiveness of decision making rather than its efficiency. Hence DSS tools are particularly appropriate for business games since it is their explicit intention to serve as a set of supportive tools assisting managers in assessing the ramifications of parts or pieces of more complex or semistructured problems [Krober and Watson, 1983, 329]. while not totally different, OR/MS techniques focus: 1) on structured problems rather than tasks where the objective, data, and constraints can be prespecified; and 2) where the payoff is in generating better solutions for given types of problems [Keen, 1978, 2]. While some authors clearly make a large issue of distinguishing between DSS and OR/MS in terms of type of problem, we simply take the viewpoint that they both represent computerized aids or techniques to decision making, and will make no particular distinction between them in this article.

While the arguments offered here are based only anecdotal evidence from business courses* in which DSS and OR/MS techniques were used, their use here has--at least theoretically--successfully overcome some of the major shortcomings raised by critics of simulations. Since there seems be a great deal of similarity among many of the general-purpose and specialized games in the management area, it is believed that the ease and facility with which DSS and OR/MS tools facilitated the games in our context make them generally applicable to related and/or similar games. (Appendix A defines general-purpose game and specialized game and provides a listing of commonly used games in each category.)

A typical general-purpose simulation:
DECIDE

DECIDE [Pray and Strang, 1980] represents the typical general-purpose management simulation, which can be used either in a business policy course, an introductory course or, as in the case at SUNY Geneseo, used for a special, one-credit

* Two games that were used were DECIDE and DECIDE-P/OM at SUNY Geneseo.

required course called Integrative Management. DECIDE has also been used for one-day management workshops held over the past five years at SUNY Geneseo for business practitioners. Initially participants are divided into teams. Each team represents management of a firm manufacturing shoes, in competition with other firms, in the simulated industry. Thereafter, teams make a series of decisions regarding variables such as price, promotion, purchase of raw materials, etc. The effectiveness of a team's decisions and a company's well-being are indicated by its stock market value following each period of play. Each team is then ranked according to the value of its stock. As is the case with many simulations, the time in which decisions have to be made is short. This is so particularly when utilizing a simulation with business practitioners as players in a one-day seminar. In addition, students frequently, simultaneously experience problems addressing 'what-if' questions and integrating concepts. Time constraints, as well as problems due to complexity noted in conjunction with the DECIDE game are characteristic of problems expressed by users of other general-purpose games.

The advent of DSS and OR/MS techniques has addressed many of these problems and can greatly alleviate their influence without adding another layer of new problems for the student. That is, the student does not have to learn a whole new computer language or be totally familiar with specialized software in order to be able to take advantage of DSS and/or OR/MS techniques. Furthermore, the simulation environment provides an exceptional opportunity for students to make some "realistic" uses of these DSS and OR/MS techniques.

To assist students and business practitioners completing in the DECIDE game and to demonstrate the use of a DSS technique, a computerized spreadsheet was designed using VISICALC TM to facilitate and/or generate 'what-if' scenarios prior to making the firm's actual decisions. This spreadsheet corresponds with the worksheet provided in the student manual of the DECIDE simulation. The worksheet is supposed to help the students organize their decisions for the firm and serves as an aid in seeing the relationships among the decision variables. However, the worksheet is somewhat static and unidimensional, and is not able to assist students in observing how changing one variable will change others. It is precisely here where an electronic spreadsheet program is advantageous.

VISICALC is a typical electronic spreadsheet program which aids in dealing with such common business problems such as calculating sales projections, income taxes, financial ratios, cost estimates, etc. VISICALC also represents one of the software packages used most commonly in business courses [Schwieder, et. al., 1983]. Features of VISICALC (and other spreadsheet software packages) include the use of windows for viewing several different parts of the spreadsheet simultaneously, procedures which allow individual cells, columns, and rows to be manipulated mathematically, and

TM VISICALC is a trademark of Visicorp, San Jose, Ca.

intrinsic functions which allow formulas to be inserted into the spreadsheet with results entered in new locations. The spreadsheet developed at SUNY-Geneseo using VISICALC allowed students to enter decisions and current values (as in the case of inventories) and determined immediately the resulting estimated production capacity, income and cash flow. The ease of initial calculation provides the students with the time and the ease such that they can ask numerous 'what-if' questions. This represents a significant departure from the customary and tedious process of filling our worksheets 'by hand' and using hand calculators to try to keep track of the firm's assets and liabilities.

Appendix B shows selected portions of a spreadsheet developed using VISICALC. In the actual usage ~as a substitute for the DECIDE worksheets) the students are given the completed template. Students then load the template into the computer entering only their decisions and current values in the appropriate cells on the template (indicated by a string of "?" following the cell) , and with that done, they are able to address those 'what-if' questions of interest. To illustrate, students frequently wish to know the ramifications of a price change on after tax income and on cash flow. To reveal these effects a student would merely enter the price which he or she is speculating about and the spreadsheet program will automatically provide the results. This effect can be made even more dramatic with the judicious use of the window option of VISICALC because students can see on one screen the decision and the subsequent result.

A specialized simulation: DECIDE-P/OM

DECIDE-P/OM [Pray, et. al., 1984] is a more complex and sophisticated game and was developed for use in Production and Operations Management courses. As with most management simulations students are divided into teams of 3 to 6 players. Each team acts as the operations managers and makes production-oriented decisions for its organization. In the simulation, the student-managed firms attempt to utilize their resources in the most efficient and effective manner. Each team has the same overall objective--to effectively manage the production function and maintain a financially viable organization. The overall effectiveness of the firm is summarized with a multicriteria objective function that includes the relative ranking of the firm in areas such as profitability, effective control of quality (both on the input and output side), materials requirement planning and inventory control, satisfying demand for finished goods, and controlling downtime ~nonproductive time)

The student-managed teams may make up to fifty-two decisions (some are optional) per period, all of which are principally concerned with P/OM topics, including scheduling labor--skilled and unskilled--for both regular and overtime, raw material purchases required for production, preventative maintenance allocations, labor training expenditures, quality control procedures for controlling defectives of finished goods, acceptance sampling procedures for raw materials, setting up the appropriate number of production centers, and purchasing historical information about the operations of the organization. Because of the nature of the simulation and the decisions that must be made, students must apply a variety of quantitative techniques in order to make meaningful decisions. For example, making decisions under conditions of risk and uncertainty, multiple regression applications, cost/benefit and marginal analysis, scheduling with LP, forecasting with time series, hypothesis testing, acceptance sampling and quality control are covered. Obviously students participating in this simulation should have some prior preparation and knowledge of such techniques. Nonetheless, student teams would frequently be forced to use hand calculators, guess work, or worse; or would riot use quantitative techniques at all--either because it was too difficult to use such techniques without a computer or because not enough time was given between sessions to use such techniques. The real problem, however, was that even with computers, students had to spend considerable time setting up computer programs and many of them just 'did not bother to do so. Hence one of the key objectives of the game, i.e., applying and understanding how various quantitative techniques were integrated, was not accomplished.

As noted below, however, this problem can be greatly alleviated by using DSS and OR/MS techniques. For example, in the specialized game of DECIDE-P/OM students have to make decisions about production and labor scheduling. In order to make reasonable decisions about production and labor scheduling, students should make use of Linear Programming and statistical procedures. Before the availability of DSS and OR/MS techniques on mainframe and microcomputers the techniques were given short shrift by students either because they were difficult to employ by hand or students found they had to write their own programs for such techniques. Now, students are able to use packages such as Lindo, SPSS and Minitab and use them in an integrated fashion. One student at SUNY-Geneseo actually developed a short computer program which generated data which was subsequently analyzed using Minitab and formed the basis of the student's acceptance program (see Appendix C). Hence, DSS and OR/Ms techniques when utilized in a specialized simulation environment can now be said to address the problems students had previously encountered in applying and integrating various quantitative techniques.

Conclusions

As stated earlier, one of the principal purposes of business simulations is to model real-world business competition and simulate the complexity of corporate decision making. Needless to say, most management games and simulations have done a good job modelling the complexity of real-world variables but have come up short in terms of allowing students or business practitioners time and/or tools enough to fully appreciate such complexity. With the advent of microcomputers and various software packages, however, more time can be spent on teaching the relationships among the various decision variables and on integrating

various quantitative techniques, rather than on the mechanics of the game itself. The development of microcomputers and appropriate computer software has increased to the degree that most Management Information System (MIS) textbooks now list DSS and OR/MS as major sections. Suffice it to say, that DSS and OR/MS techniques are becoming standard fare in both the classroom and business world, particularly for modelling what-if' scenarios for a firm or industry [Sprague, 1981, 2]. As this paper has demonstrated, DSS and OR/MS techniques can be used to enhance learning and appreciation for both general-purpose and specialized simulations. The DSS and OR/MS techniques used for both the general-purpose and Specialized business games provide students more time to spend on actual decisions without calling upon them to learn and assimilate more information and/or procedures by which to play the games.

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APPENDIX A

A general-purpose management simulation/game is one geared to helping teach, or reinforcing fundamental topics of management, economics, accounting and finance, particularly focusing on how these areas are interrelated in a business context. Generally such games require only a rudimentary knowledge of business or of their nature, intend to provide such knowledge. Some typical games are Business Decision Simulation, Business Management Laboratory, DECIDE, Executive Simulation, IMAGINIT, Microsim, TEMPOMATIC IV, The Executive Game, and V. K. Gadget Company Game.

Specialized management games refer chiefly to games that are devoted to a particular functional area, for example, economics, finance, accounting, marketing, MIS, or production. Frequently, these games are intended to be more complex and sophisticated than general-purpose games. While the degree of complexity is probably a subjective opinion, the point is that these games often require specialized or in-depth knowledge or require students to use and integrate concepts and techniques in a special area. A list of typical specialized games might include COMPETE, DECIDE-P/3M, FINANSIM, ISAP, Marketing in Action, Markstrat, and RISKM.

APPENDIX B

The following shows selected lines of a VISICALC spreadsheet which was developed to facilitate decision making when used in the simulation called DECIDE. The entire spreadsheet is 200 lines long and includes the production, income and cash flow worksheets.

```
          A          B             C           D            E               F      G          H                I
  1   DECIDE -- THREE WORKSHEETS COMB
  2
  3                                DECIDE WORKSHEETS
  4                  PRODUCTION, INCOME & CASH FLOW WORKSHEETS
  5   ****************************************************************************************************
  6
  7                  BEGINNING VALUES
  8                   ---------------
  9      900000       ???????      LEATHER INV. IN SQ. FT.
 10      500000       ???????      RUBBER INV. IN SQ. FT.
 11      600000       ???????      LABOR CAPACITY IN HRS.
 12
 13                  ESTIMATES
 14                   ---------------
 15          10       ???????      LEATHER WASTE %
 16          10       ???????      RUBBER WASTE %
 17       11.24       ???????      DOWNTIME %
 18
 19                  DECISIONS
 20                   ---------------
 21      900000       ???????      LEATHER PURCHASE IN SQ. FT.
 22      450000       ???????      RUBBER PURCHASE IN SQ. FT.
 23      400000       ???????      REGULAR LABOR HRS.
 24   ****************************************************************************************************
 25
 26                                PROCUTION CALCULATIONS
 27
 28                  LEATHER                                 RUBBER                          LABOR
 29          10      WASTE FACTOR                    10      WASTE FACTOR          11.24     DOWNTIME
 30      900000      BEGIN INVENTORY             500000      BEGIN INVENTORY      600000     CAPACITY
 31       90000      AMOUNTS OF WASTE             50000      AMOUNTS OF WASTE      57440     LOST TIME
 32      810000      AVAILABLE                   450000      AVAILABLE            532560     EFFECT CAPACITY
 33      405000      MAX PRODUCTION              450000      MAX PRODUCTION       532560     MAX PRODUCTION
 34
 35   LEATHER        MAX PROD          405000
 36   RUBBER         MAX PROD          450000
 37   LABOR          MAX PROD          532560
 38
 39   CONSTRAINED MAX                  405000
 40   DESIERED PRODUCTION              405000

 59
 60
 61   DECIDE-INCOME-WORKSHEET
 62

 77                  DECISIONS
 78                   ---------------
 79   PRICE                             26.00     ????????
 80   MAX. SALES UNITS                 415000     *** DESIRED PROD. + BEG. INV. ***
 81   SALES UNTIS                      415000     ????????
 82   REGULAR HOURS                    400000     ** ENTERED ABOVE **
 83   OVERTIME HOURS                    56287     ** ENTERED ABOVE **

106    --------------------------------------------------
107      INCOME WORKSHEET
108      ---------------- ------------
109
110   TOTAL SALES REVENUE             1.1E+07
111
112   COST OF GOODS PRODUCED
113   BEGIN INVENTORY FIN GOODS                   130000
114   LABOR (8.00 PER HOUR)                      3200000
115   OVERTIME PREMIUM                            675439
116   LEATHER USED (1.50 SQ FT)                  1350000

138   NET INCOME FROM SALES                      1026139
139   NET INCEOM FRO MARKT SCRTS                    7800
140   TOTAL TAXABLE INCOME                       1033939
141   INCOME TAXES                                496291
142   NET INCOME AFTER TAXES                      537648
143
```

APPENDIX C

The following section shows the computer program written by an undergraduate student*. It was used to develop plots of operating characteristic and average outgoing quality which served a student team in developing an acceptance sampling program to be used in playing the simulation called DECIDE-P/OM

Generating Operating Characteristic and Average Outgoing Quality Curves using Minitab

```
Steps:
  1)   Sign on
  2)   Execute Minitab
  3)   Store "Do Loop" as follows:
           MTB> STOR BINOLOOP'
           STOR> BINO N=K2 P=K1 STORE Cl
       STOR>        LET KS          = K3 + 1
       STOR>        PICK 1          THRU KS OF Cl PUT C2
       STOR>        LET K4          = ABSO(ROUN(K1*100))
       STOR>        LET C5(K4) = KI
       STOR>        LET C6(K4) = SUM(c2)
       STOR>        LET K1          = K1 + .01
       STOR>        END
  4) Name variables and setup plots
       MTB>         NAME CS IS '%DFCTVS'
       MTB>         NAME C6 IS 'PROB'
       MTB>         NAME C7 IS AOQ'
       MTB>         HEIGHT = 40
       MTB>         WIDTH = 80
  5) Initialize constants
       MTB>    LET K1      =   .01
       MTB>    LET K2      =   75
       MTB>    LET K3      =   5
       MTB>    LET K4      =   0
       MTB>    LET KS      =   K3 + 1
  6) Execute do loop
           MTB> EXEC 'BINOLOOP' 30 TIMES
  7) Calculate AOQ
           MTB> MULT CS BY C6 PUT C7
  8) Send results of one combination of n and c to printer
           MTB> OUTFILE = 'PRINTER'
           MTB> PLOT C6 FROM 0 TO .1
                    VS CS FROM 0 TO .4
           MTB> PLOT C7 FROM 0 to .1
                    VS C5 FROM 0 TO .4
  9) Repeat steps 5 through 8 above for each combination of n
       and c desired
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