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TEACHING MRP EXPERIENTIALLY THROUGH THE USE OF LOTUS 1-2-3

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ABSTRACT

The use of spreadsheets as a supplemental planning tool with simulation games is becoming relatively common [1, 3, 11]. This paper will discuss one such application. The approach discussed is unique in that the spreadsheet usage deals with the Materials Requirement Planning (MRP) problem embedded in a logistics simulation game. While most of the students had been exposed previously to MRP and some of them to spreadsheet usage, this application presented an opportunity for them to work with MRP systematically and efficiently rather than just "muddling through."

INTRODUCTION

The use of an experiential learning approach such as the live case method or a complex simulation game can provide a very rich environment for having students use specific tools to tackle subsets of the overall problem. Numerous ABSEL papers have discussed such pedagogical approaches. For example, Peters [9] discussed the use of various operations research techniques to help in the planning for a production game. Jauch and Gentry [8] discussed the use of a greatly simplified, interactive version of a business policy game to let students experiment with their decisions prior to using them in the game itself. Gentry [4] discussed the use of PERT to help students plan and complete a survey research project (a "live case") within a semester. At last year's conference, Anderson and Lawton [1], Shane and Bailes [10], and Sherrell, Russ, and Burns [11] all discussed the use of decision support systems as supplemental tools to help in planning for simulation games. Thus many ABSEL participants have come to the realization that not only do complex experiential exercises provide an interesting, enjoyable, and realistic stimulus for learning, but they also can provide a laboratory for the application of procedures taught elsewhere. This paper will discuss in detail one such application, the handling of an MRP system through the use of spreadsheet analysis.

Background

The course involved is Business Logistics and Channel Management, taught primarily at the undergraduate level. It is required of all marketing undergraduates, but is a common elective of undergraduate management science students as well. Given its resting place in the marketing curriculum, the course emphasizes the physical distribution components of logistics. However, the materials management components are covered to some degree.

Like in most courses, a divide and conquer approach is taken as topics such as transportation, warehousing, location analysis, customer service, and inventory control are covered separately through lectures and through the use of cases. The topics are clearly not independent, though, as changes in one area usually have strong effects on the other areas. For example, it is not uncommon to see decisions such as the switch to a sturdier package reducing costs in areas such as transportation, warehousing, and materials handling. Cases can cover these tradeoffs to some extent, but frequently the tradeoffs either are not very explicit in the cases or they involve certain aspects of the course which have not been covered as yet.

Thus, the systems nature of the distribution function requires the use of some type of integrative tool. Luckily, James Heskett developed such a tool when he was at Ohio State and some of his students have computerized the simulation game. The version of the Heskett game used in our courses was LOGSIMX [2]. The Game. LOGSIMX [2] was presented by DeHayes at the second ABSEL conference in Bloomington. It has been the most frequently cited logistics game at ABSEL conferences [5, 6, 7].

The game involves the production and distribution of Wondawata, an energy source that is substitutable for gasoline. Each world consists of four small markets, each of which is home to one of the four competing firms. In the geographic center of the world is a large market with about 33% of the total demand, of which each firm has 25% of the market share initially. Each firm has approximately one-half of its home market initially, and approximately one-sixth of the competitors' markets. There is no means of competing through marketing mix variables such as price, promotion, or product differentiation. Thus, product availability (both past and present) is the primary determinant of market share.

Two modes of transportation are available for both raw materials and finished goods. Varying lead times and varying vehicle load configurations make production scheduling and the distribution of finished goods quite complex at the start of game play. The product consists of three components, which are needed in different quantities (but in constant proportion) for each unit of Wondawata.

As inferred above, the production scheduling problem lends itself to an MRP approach. An insufficient number of component units has been ordered to meet gross production requirements in upcoming weeks. Consequently, all components need to be ordered by premium transportation in the short run, with lead times varying from immediate availability for two components to a week for the third. Lot sizing affects the lead times of regular transportation. Vehicle load lots are available with lead times of one to eight weeks, while less than vehicle load quantities increase lead times to two to eight weeks. Once the production levels are set (they must be set two weeks in advance of production, although they may be changed after that), determining how much of each component to order becomes a matter of making sure that four, eight, and twelve times the number of production units will be available for the respective components. Determining when to order becomes a function of using the lead times available for either of the two transportation types in vehicle load quantities. While most students adapt to this process over a few periods of game play, the use of a spreadsheet approach early can help the student organize the process more systematically and more

simply, as well as providing immediate feedback on the result of various ordering decisions.

MRP THROUGH A SPREADSHEET

While MRP is presented in most management courses as a computer system, most student exercises are provided as small, hand-calculated problems. Moving the application to a spreadsheet emphasizes the "computer system" approach that is typical of MRP, allowing the student to provide the principal inputs, prepare the process, and readily make use of system outputs in decision making within the LOGSIMX simulation.

Principal inputs to an MRP are the master production schedule and the bill of materials. In the case of LOGSflIX, the master production schedule, indicating the number of end items to be produced (units of Wondawata), is set by the student at least two weeks in advance, and can be forecast further using the general demand patterns provided. The bill of materials for each end item requires three dependent components- -eight units of Gelatin compound, twelve units of Exoticite, and four units of Heavy Water. Determination of gross requirements for each component is simply a matter of multiplying the independent demand indicated by the master schedule by eight, twelve, or four respectively, as indicated on the bill of materials. Determination of net requirements is normally accomplished using the relationship:

Net Material requirements	=	Gross material requirements	-	Inventory on hand

Calculation of net material requirements is complicated by the fact that an insufficient number of units of each component has already been ordered for production in some of the coming weeks. Additionally, lead times vary depending upon the type of transportation chosen and the quantity ordered. Hence a new relationship is required:

Net Material requirements	=	Gross material requirements	-	(Scheduled receipts	+	Inventory) on hand

Implementation of the MRP master schedule and levels may be accomplished by the student using Lotus 1-2-3. Required competencies for building such a spreadsheet include: 1) Worksheet commands (setting column widths); 2) entering labels; 3) entering formulae; 4) pointing to and editing cells; and, 5) copying ranges. Knowledge of the @SUM, @MAX, and @IF functions provides for easier formula entry, a neater spreadsheet display, and possible error checking.[1] These competencies can be easily presented in one or two class periods so that students may develop their own template. An alternative would be to provide a template to the student, but this would be encouraged only when the simulation was used in a very limited time span.

Adding each option for order placement (regular or premium transportation, vehicle-load or less than vehicle load quantities) and referencing these to the "Scheduled receipts" rows and cells corresponding to the lead time and previously placed orders will allow the student to make tentative "orders" and see the immediate results on the material requirements week by week. This approach avoids one of the potential pitfalls of beginning spreadsheet users in implementing an MRP template--circular references. Since the MRP approach proceeds backwards from the scheduled quantities and need dates and since the spreadsheet calculation moves forward, circular references are a possibility. The inclusion of the

[1]Many of the "slash" commands, **"@"** functions, and cell referencing schemes of Lotus 1-2-3 are common to other spreadsheet software (Visicalc) The Spreadsheet, MagiCalc, Supercalc, and others) such that the material presented here is not limited just to 1-2-3.

FIGURE 1
WONDAWATA BILL OF MATERIALS

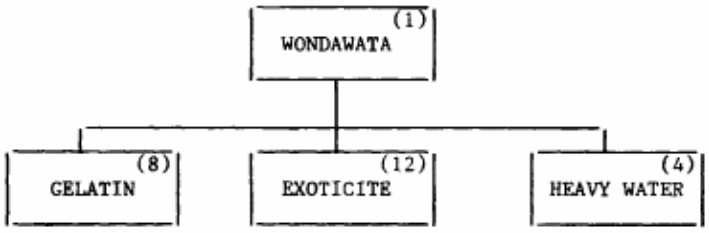

FIGURE 2
TRADITIONAL MRP FORMAT

Week number:	1	2	3	4	5	6	7	8	9
Quantity:									
Item:									
Gross requirements									
Scheduled receipts									
On-hand									
Net requirements									
Planned order release									

rows for possible orders and for scheduled receipts tends to avoid circular references while encouraging the student to work toward zero or negative net requirements through their order placement. Figure 3 shows the output from a Lotus run. The inputs are concerned only with the raw material ordering (the lower half of each section), and the rest of the information is generated from that.

Using a spreadsheet MRP implementation allows students to take advantage of the MRP outputs. Not only will the student be able to see a schedule of planned orders, but, if the template is properly designed, the student will be able to respond to changes in production levels in a more timely (and logistically less expensive) way. Students will find other applications of information from the MRP template for the LOGSIMX simulation. The MRP data alone provide potential information on "throughput" for the material handling decisions related to the sizing of the "raw material warehouse." Including the calculation of transportation costs within the template would facilitate monitoring ("auditing") of the LOGSIMX Financial Statement, as well as allowing students to see immediately the cost implications of their potential decisions.

Students who become particularly adept at the use of 1-2-3 may also extend the use of a spreadsheet to other aspects of the simulation which are numerically intensive, such as the forecasting of future production and the distribution function.

PEDAGOGICAL APPROACHES

Teaching the use of a spreadsheet in addition to the introduction of the LOGSIMX (and possibly other) simulation may seem to overburden an already heavy logistics curriculum. If students have been introduced to spreadsheet use in other (core) courses, little classroom time would be necessary to direct the implementation of an MRP spreadsheet. Presentation of the competencies required for a student with little or no Lotus 1-2-3 familiarity might require one to two

FIGURE 3
OUTPUT FROM MRP TEMPLATE

WEEK:	1	2	3	4	5	6	7	8	9
QUANTITY:	2400	2900	2900	3110	3100	2900	2900	2900	2700
ITEM: GELATIN COMPOUND									
Gross Requirements	19200	23200	23200	24880	24800	23200	23200	23200	21600
Previous Order		2000	8000						
Scheduled Receipts	0	400	23200	16880	24880	23120	23200	21600	0
On-Hand	40000	20800	0	8000	0	80	0	0	0
Net Requirements	0	0	0	0	0	0	0	1600	21600
GELATIN COMPOUND RAW MATERIAL ORDER									
Regular Transportation VL LT=1	0	23200	16880	24880	23120	23200	21600	0	0
Regular Transportation LVL LT=2	0	0	0	0	0	0	0	0	0
Premium Transportation VL LT=0	0	0	0	0	0	0	0	0	0
Premium Transportation LVL LT=0	0	400	0	0	0	0	0	0	0
Order Placement Costs	$0	$150	$75	$75	$75	$75	$75	$0	$0
Inbound Transportation Costs	$0	$5,276	$3,714	$5,474	$5,086	$5,104	$4,752	$0	$0
ITEM: EXOTICITE									
Gross Requirements	28800	34800	34800	37320	37200	34800	34800	34800	32400
Previous Order		10000	5000	12000					
Scheduled Receipts	0	0	23400	37230	27690	32400	34800	34800	32400
On-Hand	60000	31200	6400	0	11910	2400	0	0	0
Net Requirements	0	0	0	0	0	0	0	0	0
EXOTICITE RAW MATERIAL ORDER									
Regular Transportation VL LT=2	0	37230	25410	32400	34800	34800	32400	0	0
Regular Transportation LVL LT=3	0	0	0	0	0	0	0	0	0
Premium Transportation VL LT=0	0	0	23400	0	0	0	0	0	0
Premium Transportation LVL LT=0	0	0	0	0	2280	0	0	0	0
Order Placement Costs	$0	$75	$150	$75	$150	$75	$75	$0	$0
Inbound Transportation Costs	$0	$11,169	$17,919	$9,720	$11,740	$10,440	$9,720	$0	$0
ITEM: HEAVY WATER									
Gross Requirements	9600	11600	11600	12440	12400	11600	11600	11600	10800
Previous Order		5000	1000		1000			1000	4000
Scheduled Receipts		0	6800	12440	11400	11600	11600	9600	0
On-Hand	20000	10400	3800	0	0	0	0	0	0
Net Requirements	0	0	0	0	0	0	0	1000	6800
HEAVY WATER RAW MATERIAL ORDER									
Regular Transportation VL LT=8	0	14000	14000	0	14001	14000	14000	0	0
Regular Transportation LVL LT=8	0	0	0	0	0	0	0	0	0
Premium Transportation VL LT=1	0	6800	12440	11400	11600	11600	9600	0	0
Premium Transportation LVL LT=1	0	0	0	0	0	0	0	0	0
Order Placement Costs	$0	$150	$150	$75	$150	$150	$150	$0	$0
Inbound Transportation Costs	$0	$22,056	$35,705	$27,588	$33,672	$33,672	$28,832	$0	$0
TOTAL ORDER PLACEMENT COSTS	$0	$375	$375	$225	$375	$300	$300	$0	$0
TOTAL INBOUND TRANSPORTATION COSTS	$0	$38,501	$57,337	$42,782	$50,498	$49,216	$43,304	$0	$0
THROUGHPUT	57600	87000	137000	153190	139370	136720	139200	136600	101200

class periods. An alternative would be to make a template available to those who might wish to make use of a microcomputer-based decision support system. While this alternative would mean less work on the part of the student and less classroom instruction time, it might also discourage the student from using the spreadsheet for other decisions related to the simulation.

CONCLUSIONS

Using Lotus 1-2-3 for an MRP implementation coupled with the LOGSIMX simulation provides the student a hands-on experience in operating an MRP system. The LOGSIMX simulation provides feedback as to the value of the MRP implementation, and the implementation allows the student to react to changes within the simulation.

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