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TEACHING BRIEF

The Ordering Challenge: An Online Game to Introduce Independent Demand Inventory Concepts

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ABSTRACT

Students are put in the role of a manager who watches inventory levels decrease and must order at the right time and in the right quantity to minimize costs. This interactive game requires the students to race against time and has levels of increasing difficulty. It introduces the students to the concepts of holding cost, ordering cost, backlog cost, the sawtooth curve, reorder point, order quantity, ABC categorization, and continuous review systems. The game is simple and is available free online. An accompanying assignment is designed to guide the student's reflection process while playing the game.

Subject Areas: Active Learning and Inventory Management.

INTRODUCTION

One of the challenges of teaching management concepts to undergraduates is their lack of experience with the operations systems. This article describes an online computer simulation we designed to provide students an experience of ordering replenishment stock. This interactive game requires the students to race against time and has levels of increasing difficulty. It introduces the students to independent demand inventory and provides a shared experience that can be referred to when these concepts are covered in class. The game is simple and is available free online. An accompanying assignment is designed to guide the student's reflection process while playing the game.

LITERATURE REVIEW

Simulation-based training has numerous advantages for management education including providing a risk-free environment for learning and experimentation. It provides for learning in a reduced time frame while affording more learner control and engagement (Salas, Wildman, & Piccolo, 2009). In the study of supply chain management, the most well-known simulation, The Beer Game (Forrester,

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1961), is used to provide an intuitive understanding of the power of feedback and information sharing in an environment of uncertain and variable demand. The Beer Game has been adapted to be played online (Jacobs, 2000; Machuca & Barajas, 1997), to pertain to service industries (Anderson & Morrice, 2000), and to include consideration of ordering cost. Because of the chain orientation and single product nature of these games, they are not well suited to teaching the concepts of priority of control, economic order quantity (EOQ), and reorder point. There is an "active model" simulation supplied with Prentice Hall operations management textbooks (Heizer & Render, 2009) that demonstrates the mathematics of EOQ graphically as the user changes demand, setup cost, holding cost, and unit price, but this is not a simulation that puts the student in the role of an inventory manager. Our exercise does just that.

ACTIVITY GOALS

We designed the game so that the student would *experience*:

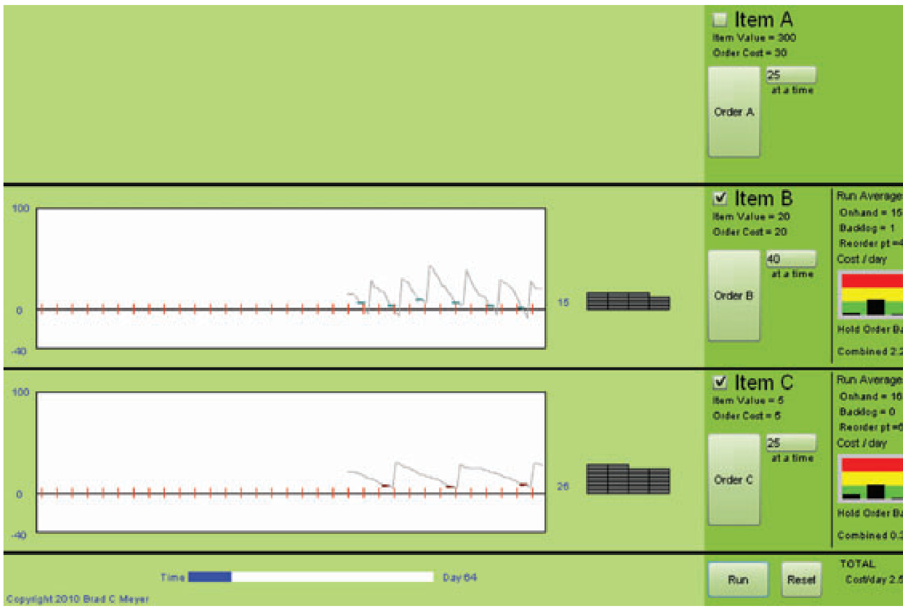
(1) How inventory level drops over time and then instantaneously spikes upwards upon receipt of an order, as is commonly described by the sawtooth curve.
(2) The incurring of holding cost, ordering cost, and backlog cost.
(3) How order quantity has an effect on both ordering cost and holding cost.
(4) The meaning of "continuous" in continuous review.
(5) How waiting too long to place an order leads to stockouts and backlog costs.
(6) The significance of the value of the inventory item in prioritizing control (ABC analysis).
(7) The tradeoff between holding cost and order cost and how, for a simple system, the two costs are balanced at the best order quantity.

We also wanted an activity that was no-cost, was relatively simple, and involved some degree of adventure with an element of competition or risk to stimulate engagement.

THE GAME

Figure 1 shows the screen for The Ordering Challenge. This online game runs in a browser, using the freely available Adobe Flash Player and can be found at http://faculty.cbpa.drake.edu/POOL/OrderSim/. The user manages up to three stock items, watching demand occur under a continuously running clock, and deciding when and how much to order. The simulation displays current inventory as a stack of boxes and also graphs the inventory level over time. There are dashboards that display run statistics and performance measures for each enabled item. The controls are simple to learn and are explained on the Web page where the simulation is found. Demand is randomly generated for each item, according

Figure 1: The ordering challenge screen layout.



to a uniform distribution with a fixed mean, which is unique for each product. The products also differ in their value and order cost.

Engagement is created in the game in two ways. First, the student is told to minimize cost and is given continuous performance feedback. The drive to get a good cost "score" provides motivation, but this motivation is amplified secondly by the fact that the game runs continuously and the student must place orders in a timely fashion. This is especially challenging when monitoring all three items. It is possible to pause the game and even to place orders, while the game is paused, but students tend to feel that pausing the game is "cheating" so most leave it running and do their best to keep up with demand for all three items.

The clock in the game allows for play up to 365 days. Levels of difficulty are implemented by the fact that the three items are separately enabled. The exercise starts with only one item to manage and increases in challenge as the other two are added.

THE EXERCISE AND ASSIGNMENT

We designed this exercise to be performed individually, outside of class, immediately before the in-class presentation of EOQ models. The exercise takes about an hour for a thoughtful student, and less time for others. The students are also assigned to read the chapter on independent demand inventory before class. So far, we have not asked the students to do the reading first or to play the game first, but it might be interesting to compare the two approaches. As this exercise is essentially an interactive case, we designed a set of questions to steer the student's thought process as they perform the simulation. The questions, along with a brief explanation, for using the simulation are available in a Word document linked at the top of the Web page where the simulation is posted. The questions call for reflection on the behavior of the system and are designed to expose principles of independent demand inventory management. We collect their answers to the questions, but we do so after class discussion.

On the class day when students come in with their answers, we use the questions on the assignment sheet as a discussion outline. We begin by talking about item B. We poll to find out the EOQ and reorder point and best cost per day attained by the students. We ask them to explain how they discovered their EOQ and what, for them, triggered a replenishment order. If students noticed that their holding cost and order cost were balanced for the best order quantity, we tell them to remember that thought and we will show why that is true later in the class period.

This is also a good time to bring up the issue of backorders. Some students will have assumed that backorders should be avoided altogether and others will have discovered that costs can be lowered by allowing some backorders. You can poll the class and compare optimal costs with and without backorders to support this point. After hearing from the students, we tell them what the optimal values are according to inventory theory.

Then, we move on to similar questions for items C and A, also asking for their insights on what was different about item C and item A. Finally, we ask them about which item they watched most closely when all three were enabled, which often, but not always, elicits a response from a student who discovered the principle of ABC analysis.

After this discussion, we move on to our presentation of EOQ models using their simulation experience as a common reference point for illustrating concepts. For example, we could discuss backorder cost and refer to the cases when the students saw boxes in red. When we show diagrams with sawtooth curves, they are no longer a mere abstraction in their thinking.

Appendix One shows the simulation parameters. We have included optimal values both with and without backorders.

RESULTS

This game has now been used with more than 500 students across the past 2 years in multiple sections of an introductory operations management class. The main result seen from the use of the activity is that class discussion of the game results is always quite animated. Students are interested to know how well they did, especially as compared to others and they come to class with some intuition and some hypotheses regarding the interactions in inventory systems.

We have collected the assignment articles for a number of semesters and compiled results that can be seen in Appendix Two. Particularly, interesting is how well the students do in determining the EOQ through trial and error. In the game, Item B is first managed by itself, then B and C together, the B, C, and A together. The EOQ for Item B should be the easiest to determine, since the student is working with only one item at that time. Students are closest to the true values for item B.

For the other two items, the students have a much more difficult time determining the EOQ. We have begun to suggest to our students that they determine EOQs for each item with only that item enabled.

CONCLUSION

The Ordering Challenge is a free online simulation that can be used to provide a shared experience for students being introduced to inventory management. The game is an engaging tool to help students gain an intuitive grasp of independent demand inventory behavior.

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APPENDIX ONE: ACTIVITY PARAMETERS AND OPTIMAL VALUES

	Activity Parameters			
	Item B	Item C	Item A	
d	3.5	1.5	3.5	Average daily demand, random with uniform distribution, range from 0 to 2 × d
D	1,277.5	547.5	1,277.5	Average annual demand for a 365-day year
i	.4	.4	.4	Holding cost rate as a % of the item value
P	\$20	\$5	\$300	Value (price) of the item
H	\$8	\$2	\$120	Holding cost rate, $i \times P$
b	32	8	480	Backlog cost per unit per year, equals 4 × H
S	\$20	\$5	\$30	Ordering cost per batch (setup cost)
L	3	3	3	Lead time in days

Optimal values assuming constant demand (backorders are allowed)				
EOQ	89	58	28	Optimal order quantity $\sqrt{\frac{2DS}{H}(\frac{b+H}{b})}$
S	17.8	11.6	5.6	Optimal maximum backlog $(\frac{H}{b+H})EOQ$
R	−7	−7	5	Optimal reorder point $-S + d \times L$
TC	\$571.88	\$93.60	\$2,712.75	Optimal total annual cost $\frac{(Q-S)^2}{2Q}H + \frac{S^2}{2Q}b + \frac{D}{Q}S$
TC/day	\$1.57	\$.26	\$7.43	Optimal total annual cost on a per day basis
Optimal values for simplified model without backorders, assuming constant demand				
EOQ	80	52	25	Optimal order quantity $\sqrt{\frac{2DS}{H}}$
R	11	5	11	Optimal reorder point dL
TC	\$639.38	\$104.32	\$3,016.41	Optimal total annual cost $\frac{Q}{2}H + \frac{D}{Q}S$
TC/day	\$1.75	\$.29	\$8.26	Optimal total annual cost on a per day basis

APPENDIX TWO: STUDENT DETERMINATION OF EOQ

Student EOQ Results

	Item B	Item C	Item A
Mean	74	35	35
Mode	90	25	25
Median	75	30	30
Standard deviation	14.8	16.5	13.3
Coefficient of variation	.20	.47	.38

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