Learning Supply Chain Management with Fun: An Online Simulation Game Approach

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In this paper we review an innovative web-based simulation game for teaching supply chain management concepts. Different from many existing turn-based simulation games, this game simulates a real-world 24/7 environment where students can make supply chain decisions and apply knowledge learned in class. We also discuss how to integrate this educational game into an undergraduate supply chain management class. The game was evaluated in an undergraduate supply chain management class at an AACSB school. The student evaluations indicate that most of the students enjoyed playing the game and preferred this simulation game approach to traditional teaching methods.

I. INTRODUCTION

As more and more companies and schools recognize the strategic importance of supply chains, supply chain management courses have become popular in many business schools and some engineering programs. Designing a balanced curriculum is crucial for teaching the subject effectively; the curriculum used by many top graduate business schools is dominated by case discussion and supplemented with lectures and guest industry speakers (Johnson and Pyke, 2000). These traditional teaching methods can help students understand supply chain management concepts, but they cannot replicate the dynamic 24/7 environment supply chain managers must face.

Online simulation games are alternative educational and training method, which can simulate a real-world 24/7 environment and keep a balance between theory and practice. With the advent of internet technology, online simulation game has recently become a more and more popular teaching tool for students to be actively involved in the educational and training process. In this paper we introduce an online simulation game, Supply Chain Game, developed and hosted by Responsive Technologies (www.responsive.net). In this game, students can actively manage a supply chain on a continuous basis, develop a set of supply chain related managerial skills, and apply theories to practice.

The objective of this paper is to describe and review the online Supply Chain Game and illustrate how the game approach helps students learn supply chain management concepts actively and effectively. The paper describes the important aspects of the game and explains how professors may effectively integrate this game into their teaching curriculums.

The remainder of this paper is organized as follows. Section 2 briefly reviews the related literature on supply chain management simulation games. Section 3 introduces the Supply Chain Game and students’ reactions. Next, we discuss on the link between supply chain management concepts and the simulation game in Section 4. Section 5 presents tips on teaching and grading. The students’ evaluations...
and instructors’ work load will be discussed in Sections 6 and 7, respectively. The paper concludes with a summary of the game.

II. LITERATURE REVIEW

Few simulation games are available for teaching supply chain management. The most well-known game, beer game, was developed at MIT in the 1960s to demonstrate the bullwhip effect in an inefficient supply chain. The early version of beer game is a board game, which can be played in class but consumes a significant amount of class time. The most recent versions are played with computers through the internet and include computer games developed by Simchi-Levi et al. (1998), an internet version by Jacobs (2000), a beer game with stationary demand by Chen and Samroengraja (2000), a near beer game (2003), and a modified beer game by Sparling (2002). Despite these updates, the limitations of the beer game are twofold. First, the game only focuses on a specific principle of supply chain: the bullwhip effect and its causal factors. Second, the game is a turn-based game, which means that during the game participants make a decision, submit that decision, and then later receive response on their performance and the consequences of their decisions. This method fails to replicate the continuous nature of the real world.

Another turn-based game was recently developed by the Harvard Business School. This interactive online simulation game allows students to manage the complexities of a global supply chain in a mobile phone company (Harvard Business School, 2004). However, students still gain limited experience in dealing with a 24/7 global supply chain environment. Other simulation games illustrate supply chain principles, but have some limitations. Jackson (1995) designed a distribution simulation game in a two level distribution supply chain. However, the game is turn based and cannot be played online. Anderson and Morrice (2000) proposed a simulation game to teach service oriented supply chain management principles, but their homegrown game is not commercially available. Trading Agent Competition Supply Chain Management game (TAC/SCM, 2002) was well-known among researchers, but it is not suitable for teaching purpose.

More recently, Corsi et al. (2006) developed a “Distributor Game”, which focuses on the distribution process in a global real-time supply chain. Different from other turn based simulation games, this game replicates a real world experience on a 24/7 basis. The game is still in the testing phase and is not commercially available for interested supply chain instructors. After reviewing the existing supply-chain games, we realized that the Supply Chain Game developed by Responsive Technologies does not have the limitations of other games. The game is completely web-based and played in real time (not turn-based). The game is also commercially available and affordable by students.

III. DESCRIPTION OF THE SUPPLY CHAIN GAME

The Supply Chain Game is an internet based supply network simulator, which was developed by Professors Sunil Chopra and Philipp Afeche at the Kellogg School of Management at Northwestern University and adopted by schools in 2005. During the simulation game, teams of three to five students control a virtual company, Jacobs’ Industry, which produces an industrial chemical that can be mixed with air to form foam. Student teams expand and manage the company’s supply network on the fictional continent of Pangea and an adjacent island of Fardo (See Figure 1). Each student team has identical demand and supply information and makes decisions on demand forecasting, production and inventory control, supply network design, and transportation options.

The supply chain game consists of two assignments: one region game and network game, each of which lasts for one week. For each assignment, the student teams’ objective is
to maximize their cash balance generated by the foam technology over the simulation periods and minimize the inventory. At the end of the game the team with highest cash balance wins. Each assignment is briefly described below.

**FIGURE 1: MAP OF SUPPLY CHAIN GAME**

1. **One Region Game**

In the one region game a single factory and a single warehouse operate in the region of Calopeia (see Figure 1). Headquarter holds relevant demand and financial information, which is available for the past two years at the beginning of the game. Demand for the company’s chemical product occurs only in the Calopeia region and is very seasonal, peaking in the summer and reaching a low point in the winter months. Customer orders arrive randomly during the day and order size (number of drums) varies. After learning forecasting techniques in class, most student teams can recognize the importance of demand forecasting and apply those forecasting techniques to this game.

At the beginning of the game, the factory’s production capacity is set to 20 drums per day, which is significantly below average demand. Additional capacity can be purchased but it is costly and such an expansion takes three months to complete. All the capacity can’t be retired or salvaged at the end of the game. Most students figure out the initial production capacity is insufficient and they need to add capacity to meet demand. Some teams set the capacity level very high and fail to recognize how to use buildup inventory to meet seasonal demands. Other teams performed better because they made good use of seasonal inventory and set their capacity to a reasonable level (around mean forecast demand).

The continuous review inventory model is used for inventory control in this game. Production of a batch is triggered when the finished goods inventory falls below the reorder point set by student teams. Some student teams use the continuous review model taught in class to calculate the order quantity and reorder point, the two parameters. But the calculated parameters may not always be applicable because the seasonal demand violates certain model assumptions. As a result, student teams use the calculated parameters coupled with trial-and-error to dynamically make their inventory decisions.

The virtual Jacobs industry hires a third party logistics provider and ships the drums from factory to the warehouse as soon as production is complete. The warehouse sends drums to customers once orders are received. The drums can be shipped either by truck or by mail. The trucking option is cheaper if the factory ships drums on full trucks, while the mailing option has higher shipping rates. Students also know the fact that new foam technology is under development at Jacobs and all production capacity and inventory of the current foam will be obsolete and worthless at the end of the game. Most student teams reduce or stop production at the end of the game to minimize the risk of excessive leftover inventory. Student teams also recognize the need to switch from trucking to mailing at the end of the game in order to reduce transportation costs. Compared to the second network game, the first game is relatively easy and requires fewer supply chain related decisions. But the purpose of the first game is to familiarize students with the game’s instructions and basic problems. Once they finish the first game, students are more confident playing the network game,
which is more complicated and involves more supply chain decisions.

2. Network Game
In the network game, Jacobs Industry wants to expand into all five regions of fictional continent (see Figure 1). Students begin the game with two years history of demand in Calopedia, which is identical to demand in the first game, and a 90 day history of demand in the other four regions. Except for the linear demand in Sorange, the expected long-run demand pattern in other three regions is non-seasonal, neither upward nor downward.

Facing the new markets’ demand, student teams need to decide when and where to build new warehouses and factories to balance supply and demand. Students are told that it takes 90 days to either construct a new factory or to add capacity to an existing factory and it takes 60 days to build a warehouse. Before students make any expansion decisions, they should consider the construction time. Most students also recognize that the factory and warehouse in the Calopedia cannot effectively satisfy the demand from all regions. Some student teams adopt a wait and see strategy and simply react to demand. Better student teams use break-even analysis to estimate the break-even order quantity for a new factory/warehouse. They then compare the estimates to regional demand to decide if they should add a factory/warehouse in each region.

Like in the one region game, the continuous review inventory model is used to control production and inventory in factories. Student teams decide how to schedule production in each factory and how to manage inventory in the supply chain. The shipping options are the same as in the first game, but shipping rates and lead times are different for different regions. Most student teams figure out prioritizing shipping in each warehouse so they can first meet the more profitable local demand and then meet demand outside of the region. Better student teams use transportation methods covered in class to decide which warehouses should serve each target market and how to minimize transportation costs from factories to warehouses.

FIGURE 2: SAMPLE NETWORK GAME SOLUTION

As in the first game, new technology will replace the current one and demand for the current technology will reach zero at the end of the simulation. In the first game most student teams ramp down production and reduce inventory to prevent obsolescent costs at the end of the game. Figure 2 shows a student team’s solution, with a final cash position of $23,421,019.87, at the end of the network game.

IV. LINKAGE BETWEEN SUPPLY CHAIN CONCEPTS AND THE GAME

The Supply Chain Game offers a great opportunity to link different real-life scenarios to a variety of concepts and techniques that are critical to managing supply chains in the real world. These concepts and methods include demand forecasting, inventory control, production planning and scheduling, network design, and logistics. Traditionally, these concepts are taught in a certain order according to a textbook, but the simulation game helps students dynamically link them together as an integrated skill set. Table 1 summarizes the
linkage between supply chain management concepts and the game.

To integrate the game into an undergraduate supply chain management course, instructors should cover forecasting and inventory control concepts before students play the one region game. Typically, capacity management and break-even analysis have already been covered in an introductory operations management; however, instructors may review these concepts before the first game. Likewise, the concepts for the network game should also be covered in class before the game starts.

V. LINKAGE BETWEEN SUPPLY CHAIN CONCEPTS AND THE GAME

The Supply Chain Game requires less lecture time for instructors. Several days before the game starts, a 30 minutes in-class introduction should establish the basic setting of the game and the instructor’s expectations. If possible, a computer lab session is very helpful to allow student teams to explore the game and ask questions about it. Also students should have access to a history of the game before the game actually starts, so they can develop strategies in advance. After each game, a follow-up in-class discussion summarizes the important learning points for each simulation game.

We assess the students’ learning using three aspects of performance: the write-up report, the simulation performance, and the team presentation. The grading distribution is 60% report, 20% performance, and 20% presentation. The report should describe the student teams’ actions and analyze whether other choices would have allowed the teams to do even better. The report is graded based on the effectiveness of students’ explanation and application of knowledge learned in class. The performance portion is based on student teams’ final cash balance and is designed to give student teams incentive to obtain better cash positions. The presentation component is graded on students’ ability to effectively present their analysis. In addition, the total weight of the simulation game accounts for 15 to 20 percent of students’ final course grade.

V. TEACHING AND GRADING

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<table>
<thead>
<tr>
<th>Game</th>
<th>Game Attribute</th>
<th>Supply Chain Management Concepts and Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>One region game</td>
<td>Seasonal demand</td>
<td>Winter’s model, Box Jenkins technique.</td>
</tr>
<tr>
<td></td>
<td>Factory capacity planning</td>
<td>Different capacity management strategy: Proactive, reactive, and straddle strategy.</td>
</tr>
<tr>
<td></td>
<td>Factory inventory planning</td>
<td>Continuous review inventory model with reorder point and order quantity</td>
</tr>
<tr>
<td></td>
<td>Transportation planning</td>
<td>Financial analysis and break-even analysis</td>
</tr>
<tr>
<td>Network game</td>
<td>Supply chain strategy</td>
<td>Fisher’s supply chain management strategy matrix, efficient or responsive supply chain</td>
</tr>
<tr>
<td></td>
<td>Demand in different regions</td>
<td>Regression analysis, moving average, simple exponential smoothing, Holt’s model, Winter’s model</td>
</tr>
<tr>
<td></td>
<td>New warehouses and factories</td>
<td>Break-even analysis, cost benefit analysis, risk pooling, network design</td>
</tr>
<tr>
<td></td>
<td>and planning</td>
<td>Cost benefit analysis, transportation mode selection, transportation method of linear programming</td>
</tr>
</tbody>
</table>

TABLE 1: LINKAGE BETWEEN SUPPLY CHAIN GAME AND SUPPLY CHAIN MANAGEMENT CONCEPTS
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**VI. STUDENT EVALUATION**

To assess the effectiveness of the simulation game, we conduct a student evaluation survey in an undergraduate supply chain elective class at an AACSB accredited school. Most of the students were management majors in their fourth year of college. Most students had completed an introductory class in operations management before taking this course, but none had experience playing web-based simulation games. The students were between 20 and 25 years old.

Based on the research of Ruohomaki (1995) and the reference listed in his paper, we designed and outlined nine survey questions to understand the effects of simulation game on three levels: effects on individuals, effects on group behavior, and effects on later activities. Listed in Table 2, the survey questions asked students to rate different aspects of their experience with the game on a five-point Likert scale, with 5 indicating “strongly agree” and 1 indicating “strongly disagree”. The first four questions were designed to evaluate effects on individuals, such as cognitive learning outcomes and impacts of the game on participants’ attitudes. The fifth question focused on the effects of the game on groups of participants.

<table>
<thead>
<tr>
<th>Number</th>
<th>Survey question</th>
<th>Average score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Simulation game helped in understanding basic concepts in supply chain management</td>
<td>4.06</td>
</tr>
<tr>
<td>2</td>
<td>The game increased my interest and knowledge about supply chain management</td>
<td>3.94</td>
</tr>
<tr>
<td>3</td>
<td>I frequently found myself actively thinking about the simulation game and what decisions I should make</td>
<td>4.09</td>
</tr>
<tr>
<td>4</td>
<td>The game improved my decision-making and problem solving skills</td>
<td>3.94</td>
</tr>
<tr>
<td>5</td>
<td>I better communicate and cooperate with my group members and share knowledge with them via the game</td>
<td>4.03</td>
</tr>
<tr>
<td>6</td>
<td>I applied the lessons learned from the game to the real-life situations</td>
<td>3.72</td>
</tr>
<tr>
<td>7</td>
<td>The game is a positive contribution to the curriculum</td>
<td>4.06</td>
</tr>
<tr>
<td>8</td>
<td>I prefer the simulation game approach to conventional teaching methods</td>
<td>4.13</td>
</tr>
<tr>
<td>9</td>
<td>I recommend the game for future operations management courses.</td>
<td>4.09</td>
</tr>
</tbody>
</table>
The sixth question tested the transfer of skills, the generalization of knowledge, general principles, or application of skills from the game to a variety of real-life situations. The last three questions were designed to examine the efficacy of the simulation game compared to other teaching methods.

Based on 32 students’ responses, we tabulated the average score for each survey question as shown in Table 2. The results were positive for all effects of simulation game. Most of students thought the simulation game helped them better learn supply chain management, effectively communicate and cooperate with their group members, and apply the knowledge to the real world. Students clearly preferred the game approach to other teaching methods. The sixth question has the lowest score among the nine questions, which may be because most undergraduate students, particularly those who are not working, do not have opportunities to apply the lessons learned from the game to the real-life situations.

VII. INSTRUCTORS’ WORK LOAD

Instructors have three types of work: technical, administrative, and grading. Based on our teaching experience, these work loads are relatively moderate. First, instructors should check the availability of certain software at computer labs. Since Java platform is the only software needed for this game, instructors should guarantee the availability of the software at campus computer labs. Instructors should also take responsibility for solving technical problems that students encounter throughout the course, such as game connection loss and unexpected simulator interruptions. Secondly, instructors will have some administrative work. The company offering the Supply Chain Game has no online payment method, so instructors must either collect registration fees from students directly or coordinate with the campus bookstore to sell the registration codes as needed. Instructors should ensure all students’ registration before the game starts. Instructors may help students register their teams during a computer lab session or office hour, for example.

Finally, grading requires a significant amount instructor time. If group presentations are required, instructors also need to evaluate them. Depending on class size, the grading time may vary from several hours to days.

VIII. CONCLUSIONS

As an excellent complement to traditional teaching methods, the Supply Chain Game is an effective and appropriate pedagogical approach for teaching supply chain management concepts. The simulation game provides students with a hands-on opportunity to apply knowledge and concepts in a real world 24/7 environment. Students interact with the game and immediately see the impacts of their decisions on a supply chain. After playing the game, students better understand supply chain concepts and effects of their decisions on inventory, distribution, and profit. According to student evaluations, most students enjoy playing the game and prefer this simulation game approach to traditional teaching methods.

IX. REFERENCES


