

Enhance supply chain dynamics education: Evaluate insights from beer game simulations.

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Abstract

With the rapidly changing global trade environment, consumer preferences and sustainability issues are becoming increasingly prominent, and supply chain management issues are becoming increasingly important. The purpose of this paper is to explore a newly designed game simulation teaching software, Beer Game, which introduces its development and theory. The software will provide consumers' true experience, by utilizing this application learners will simulate playing different roles to take the challenges of competing in the marketplace in the modern supply chains.

Therefore, the experience of the beer game immerses learners with great significance in understanding the concept of supply chain management during the competition. Through a practical experience, the game starts with running in the marketplace, to experience the results of the business performance. Students had positive responses with highly engaged attitudes towards the Beer Game system. Instructors facilitate the operations with satisfactory results.

Keywords: Supply Chain Management, Game Teaching, Beer Games, Bullwhip Effect

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Introduction

Supply chain management involves various important activities in the modern industrial and global commercial world. From the supply of raw materials upstream side to the middle stream side of production, manufacturing, and the downstream of distribution, to sales, etc., those will affect all parties of stakeholders. And in an increasingly globalized and connected world, supply chain management has become more complex. As companies are constantly striving to optimize the management of their supply chains, it is important to understand the performance of supply chain management and the basic principles and dynamics that affect its operations (Otto & Kotzab, 2003).

Because supply chain management is so complex, it is more than difficult to teach because the various factors occur all at once and affect each other simultaneously. When facing a changing dynamic world, it is not easy to see it through pure observation, so with the help of computer simulation systems, managers can quickly grasp the subtle information and take appropriate and quick action from the competition, when there is a stimulus there will be a response. Similarly, it would be of great help for students to be aware of their learning if they could quickly experience the subtle changes in the result of the decision simulation system. Simulation allows students to quickly understand the changes through market competition, due to a game-based theory, students will feel the actual real world.

Computer-based teaching methodology has been evolved for a long time (Kulik & Kulik, 1986). It is a learner-based theory, and the simulation takes care of learners' psychology, theoretically and practically. While applying the supply chain management theory, many scholars have tried to develop more appropriate teaching methods through game-based simulation. The Beer Game is one of the most well-known examples among all in supply chain management.

Beer games are a powerful tool that can provide valuable pedagogical insights into the dynamics of the supply chain, Beer Game simulation software was developed by MIT in the late 50s in the 20th century. It started as a demonstration of the complexities of supply chain management, where it has been tested over a long period and become relevant to today's supply chain challenges.

The main purpose of the current beer game is to demonstrate the importance of collaboration, communication, and information sharing among the discussion in the classroom while students role-played as supply chain partners. The game demonstrates the challenges of managing inventory, demand fluctuations, and the bullwhip effect while simulating the need for a beer distribution system with participants taking on the roles of retailers, wholesalers, distributors, and breweries.

The core experience of the beer game applies great significance in the supply chain management system. As supply chain issues were the key issue for organizations that grapple with global disruptions, rapidly changing consumer preferences, and the growing importance of sustainability, the principles derived from the beer game provide valuable guidance for navigating these challenges.

This article will explore the history and theory of the beer game. It begins with a summary of the history and goals of the beer game, followed by a discussion of its main lessons. Later explain their application to contemporary supply chain challenges and real-world examples of successful implementation.

Literature Review

Supply chain management

A supply chain is a network between a company and its suppliers that is used to produce a specific product and distribute it to the final buyer. Supply chain networks include different activities, people, entities, information, and resources. The supply chain also represents the steps taken to deliver a product or service from its original condition to the customer. Supply chains are developed by companies so they can reduce costs and remain competitive in a business environment. It's important to know how to manage your supply chain in the right way.

Supply chain management is the management of the flow of goods and services, including all the processes that transform raw materials into final products. It involves actively streamlining the supply-side activities of a business to maximize customer value and gain a competitive advantage in the market. Supply chain management represents the efforts made by suppliers to develop and implement a supply chain that is as efficient and economical as possible. The supply chain encompasses everything from production to product development to the information systems needed to guide these undertakings (Kouvelis et al., 2006).

Supply chain management attempts to centralize or connect the production, transportation, and distribution of products. By managing the supply chain, companies can cut excess costs and deliver products to consumers faster. This is achieved through tighter control over internal inventory, internal production, distribution, sales, and inventory of the company's suppliers. It is based on the idea that almost every product that enters the market is the result of a joint effort by the various organizations that make up the supply chain. Although supply chains have been around for a long time, most companies have only recently started to look at them as a value-added to their operations (Fawcett, et al.,2008).

Bullwhip effect

The bullwhip effect is an important phenomenon of coordination problems in traditional supply chains. (Wang & Disney, 2016). It refers to the role that cycling order volumes play as the supply chain moves upstream to production. Even when demand is stable, small changes in demand at the retail side may amplify dramatically upstream at the end of the supply chain. The effect is that the number of orders becomes very volatile. One week it is very high, then the next week becomes zero. The terminology was first coined around 1990 when Procter & Gamble found that order patterns in its baby diaper supply chain were erratic and amplified. Therefore, the bullwhip effect is an amplification of changes in demand. It moves the chain upstream through supply, resulting in inefficiencies, stockouts, or overstocking.

As a result of the bullwhip effect, a series of inefficiencies have emerged throughout the supply chain, as follows: (Kumar et al., 2007)

- a. High (safety) stock levels
- b. Poor customer service levels
- c. Low-capacity utilization

- d. The problem of demand forecasting is even more acute
- e. High costs and low levels of intercompany trust

While this impact is not new, it remains a timely and pressing issue in contemporary supply chains. In general, the bullwhip effect occurs due to: (Kumar et al., 2007)

- I. Order batch: This occurs when each member in the chain orders more than it needs, distorting the quantity of the original demand.
- II. Price fluctuations: Special discounts and cost changes can cause buyers to take advantage, leading to irregular production and distorted demand.
- III. Misuse of demand information: Past demand information is used for new estimates without taking into account fluctuations.
- IV. Lack of communication: This can lead to limitations when processes don't work effectively, which often happens when organizations identify product needs in different ways at different points in the supply chain.
- V. Free Return Policy: Customers may inflate demand due to shortages, and if customers are unable to return their products, retailers will continue to inflate their needs, cancel orders, and result in a surplus of products or materials.

Game teaching

Game Simulation through play, also known as gamification, is the use of gamification to learn to play theory. It is currently a popular teaching methodology and a powerful educational tool. Gamification of Learning is the holistic way of integrating all the learning elements into activity scenarios so that the classroom can truly experience real-world cases. but increases game mechanisms to trigger students' motivation to learn the simulation, so that students can enjoy the process of learning it, and then obtain the internal autonomy motivation.

It is human nature to play with teammates with games and to transform the love of games into motivation, learners' efforts can be multiplied with less effort. This is at the heart of gamers' chemistry.

At present, there are two tendencies in this viewpoint: The first view cites the theory of assessing secondary school learners through the use of educational game software or e-textbooks, to connect the content with players or online competitions, which will guide students while learning, while avoiding the rigidity and boredom of the traditional one-way teaching. Another view is that games are inherently. Therefore, by studying the characteristics of the game and using these characteristics to transform the mechanics of learning the game, the learning becomes a fun and interesting interaction in itself - rather than expressing the content through the game. This view is mainly found in European and American countries, especially New Zealand.

At present, the research on game chemistry has achieved initial results in Europe and the United States. Many schools incorporate game-playing elements into their teaching, especially activities that require physical exertion. For example: in the Game of Softball while asking students mathematical questions, so that students can come up with answers while playing and learning the experience and observation at the scene of catching the ball, which shows a more desirable result.

Beer Game

The beer game was invented in 1960 by Jay Wright Forrester of the MIT Sloan School of Management. The Beer Game is based on the research theory of system dynamics (Riemer, 2008; Kimbrough et al., 2002). Beer Game is a game simulation system developed by the Massachusetts Institute of Technology in the late 50s of the 20th centuries. It's a powerful tool that can provide valuable insights into the dynamics of supply chain management. Originally intended to illustrate the complexities of managing supply chains. As time evolves the Beer Game has been proven over time and is now functional enough to provide relevant experience and teaching applicable to today's supply chain challenges.

The beer dispensing game is an educational game that allows gamers to experience the typical coordination problems of supply chain management processes. It mirrors a role-playing simulation in which many participants play with each other. The game itself represents a supply chain with uncoordinated processes that are problematic due to a lack of information sharing (Kumar et al., 2007). The game outlines the importance of teams for information sharing, exchanging ideas and concepts of management, and collaboration throughout the whole supply chain process. Due to a lack of information, suppliers, manufacturers, salespeople, and customers are often blind-sided in predicting and understanding what the real demand is.

The most interesting part of the game is that each group has no control over the other part of the supply chain. As a result, each group only has limited control over its part of the supply chain. Therefore, the group can dramatically impact the entire supply chain by ordering too much or too little, leading to a bullwhip effect. Meanwhile, the orders of one group are also highly dependent and interlinked with the decisions of other groups (Riemer, 2008).

Research Methods

The rules in the beer game

In the Develop Beer game, a total of four stages of supply chain units are designed for participants to participate in the game. Each participant is responsible for the production and delivery of beer: the factory is tasked with producing the beer, and the other three stages of delivering the beer until it reaches the customer at the lower end of the supply chain. Therefore, the goal of the game is to meet the needs of customers with minimal backorders and inventory expenditures.

The beer game is played for a total of 24 rounds at a time, and each round must follow the following four steps:

1. Check Delivery: Check how many units of beer the wholesaler has delivered to the player.
2. Check Order: Check how many pieces the customer ordered.
3. Serve Beer: Serve as many beers as possible to meet the player's needs. In this game, this step is automated.
4. Make order decisions: Decide how many units you need to order to maintain inventory.

As mentioned earlier, there are four stages, manufacturers, distributors, suppliers, and retailers, there is a two-week communication gap for upstream orders, and there are two weeks of supply chain delay for downstream products. Holding excess inventory incurs a 1-point cost, and any backlog of orders also incurs a 1 point cost (which means old backlog + orders - current inventory). In the game, players cannot see anything other than the message conveyed to them through a piece of paper with a number written on it, indicating an order or product. The retailer draws the customer's demand from a deck of cards, the manufacturer places an order, and then turns it into a product within four weeks (Kimbrough et al., 2002).

Players in the supply chain look at each other and try to figure out what the problem is. The result is decided by the team with the lowest total cost. At the end of the report, it was explained that these feelings are common and that responses based on these feelings in the supply chain create a bullwhip effect (Sterman, 1989). The game was played in a very transparent manner, and the results illustrate the valuable lesson that poor system understanding and poor communication can have an impact even for relatively simple and idealized supply chains. Although players often cite the lack of perfect information about customer orders as the main reason for their team's poor performance in the game, an analysis of the minimum possible score for using the optimal strategy under different conditions shows that the expected value of perfect information is 0. Standard games (Thompson & Badizadegan, 2015) and simulations that include providing perfect information to players still show teams underperforming (Croson et al., 2014).

Experimental Methods

To find out whether the game is in line with the pedagogical principles, we designed a three-step assessment scheme as follows:

1. Gamification Assessment Step 1: Analyze the level of need for "motivation" in the classroom
2. Gamification Assessment Step 2: Screening the gamification elements that are suitable for the classroom
3. Gamification Assessment Step 3: Establish a play-based pedagogy that can be implemented

Gamified thinking refers to how to introduce gamified theory into the classroom in 3 steps so that teaching can be more in line with the teaching objectives and make students enjoy learning the game.

Gamification Assessment Step 1: Analyze the level of need for "motivation" in the classroom.

The degree of motivational need in the classroom refers to the degree of motivational need that causes students to learn the game. The first step in gamified theory is to analyze the level of motivational needs in the classroom because each lesson needs to motivate students who are different!

Not all lessons need a gamification element to motivate the teaching and learning to run smoothly, so an analysis is needed to assess whether and to what extent integration is really needed. In fact, when conducting an analysis, it is necessary to check the "Learning objectives", "Learning time", "number of students", "experienced time per person", etc., and then evaluate whether the game to be used is directly proportional to the Game learning effect behind it. If the game is played for too long but the Game effect does not increase, then it is easy to become just playing the game and not a lesson, that misses the learning objectives.

On the other hand, if the experience is too short and the essence of the activity is not conveyed to the students, then the purpose of the experience is also lost.

Gamification Assessment Step 2: Screening the gamification elements that are suitable for the classroom "Gamification elements" refers to the use of game elements in teaching activities, so that the classroom is no longer just a teaching mode of "teachers teach, students learn". By selecting suitable gamification elements, the lesson can be carried out more smoothly and in line with the teaching theme to achieve the educational purpose. To enable students to actively participate in the curriculum and learn Xi independently, breaking the established framework and model of "teaching and learning". However, if gamification elements and teaching games are applied arbitrarily without screening, the teaching progress and time will be delayed, the teaching theme will deviate from the teaching theme and the learning Xi will be ineffective. Filter the "gamification elements" in two steps:

1. Evaluate what game elements need to be used in this teaching activity, such as the rewarding mechanism, cooperation element, competition relationship, luck component, etc., and put game elements into the activity to add some fun for the students.

2. For example, if the topic of the lesson is "numeracy" in mathematics, then you can find games that require computation. Or, if the theme of the course is "communication", then find games with their own communication and interaction mechanisms, so that students can learn directly from the process of playing.

3. The core objectives of your teaching:

3.1) What is the pedagogical purpose of the lesson?

3.2) How did you achieve the gamification element?

3.3) How can you help students converge the game experience into the desirable result?

Gamification Teaching Evaluation Step 3: Establish a practical game teaching method.

Gamification teaching method refers to the use of game elements to improve students' motivation, experience and engagement of learning, and ultimately achieve the purpose of education. Another in-depth teaching method, I think is the "game-based simulation method", which aims to make the teaching activity itself a game by applying game mechanics, such as designing a board game with theme-based objectives, while in the classroom. If you don't have a game-based pedagogy that can be implemented, you may distract the learners. So, to misuse or be inappropriate for the game elements in the class. Here is the list that we designed for the student to answer as follows:

Table 1 List of questions (students)

item	Issue
1	I think the content of this game is more lively and vivid.
2	I think this game-based learning is easy to use.
3	I like to learn Xi game-based Xi supply chain management subjects.
4	I think the knowledge in the supply chain management course can be applied to the simulation game.
5	Overall, I think this game simulation is very helpful for students.

Based on the above three principles of evaluation, we have also designed the following assessment form:

Table 2 Interview topics (teachers)

item	Gamified Teaching Assessment Steps	issue
A	The degree of "eliciting motivational needs" in the classroom is good	<p>A1: The game is designed at the right time to motivate students while learning the game.</p> <p>A2: The number of participants in the teaching of this game is appropriate to motivate students learning.</p> <p>A3: The hands-on experience of the students in this game teaching is very appropriate and can arouse students' motivation learning.</p>
B	The "gamification element" in the classroom is suitable	<p>B1: Appropriate reward mechanisms are cited in this lesson.</p> <p>B2: In this lesson, there is a reference to the element of cooperation.</p> <p>B3: There is a reference to competing relationships in this lesson.</p> <p>B4: There is an element of luck in this lesson.</p> <p>B5: This course achieves the core objectives of supply chain management teaching.</p> <p>B6: students can reflect on the learning objectives of the lesson through play.</p>
C	The Play Pedagogy in the classroom is practical	<p>C1: Is a game Learning method appropriate?</p> <p>The whole process of the C2 game meets the teaching requirements of supply chain management.</p>

Table 3 Student satisfaction questionnaire

item	issue
1	Do I think the content of this game review is lively and vivid?
2	I think this game is easy to learning?
3	I like this way of using games to experience supply chain management subjects.
4	If I can, next time I would like to use this game teaching.

Table 3 (Continued)

item	issue
7	In game Xi, I know exactly what knowledge to use to pass the level successfully.
8	I hope that in the future, in the school curriculum, we can use this game to learn?
9	I would love to discuss and share tips and tricks with my classmates.
10	I think the whole learning process will be more interesting because I can compete with my classmates in the process of learning.
11	During the game, I struggled to solve problems so that I could get through the level?
12	Overall, I think this game teaching is very helpful for my learning.

Results & Discussion

Experiments and Sampling

The whole teaching/learning process was conducted in July 2003 at the Department of Business Administration of a university in Taiwan, with a class of 32 students participating, and the teacher questionnaire was filled out by 9 teachers from the Department of Marketing and Distribution of the university.

Gamification Teaching Evaluation Results

After the evaluation of 9 professors, the results of this gaming evaluation are shown in Figure 1. The ordinate in the figure is the quality of the assessment, and the abscissa is the evaluation indicator of gamified teaching, as shown in Table 2.

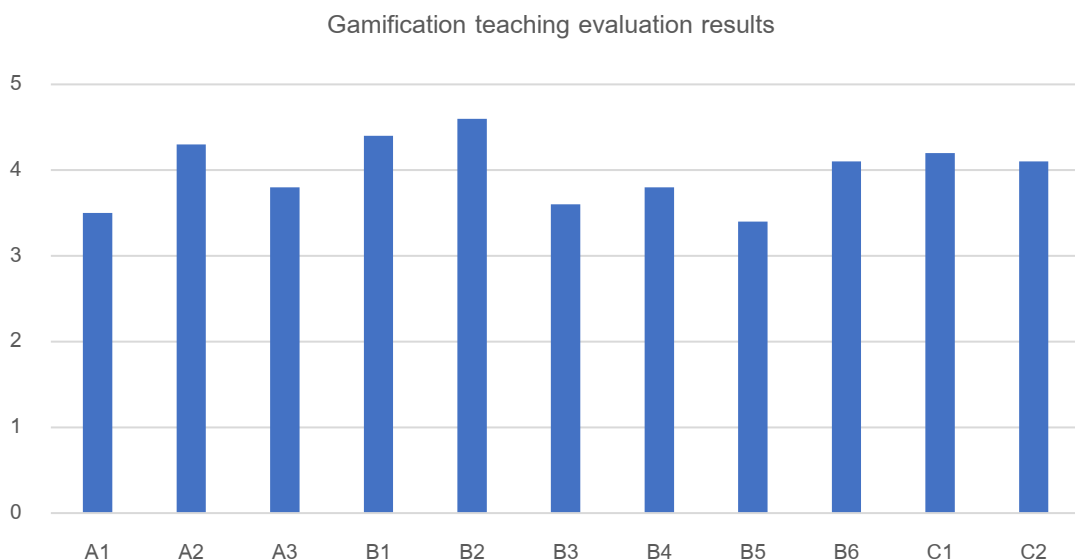


Figure1 Evaluation results of gamified teaching

As you can be seen from this figure, the scores of each evaluation index are above 3, which means that the function of this game teaching can meet the requirements of learning objectives.

Analysis of students' perceptions of game learning

The survey results of students' views on game learning are shown in Figure 2.

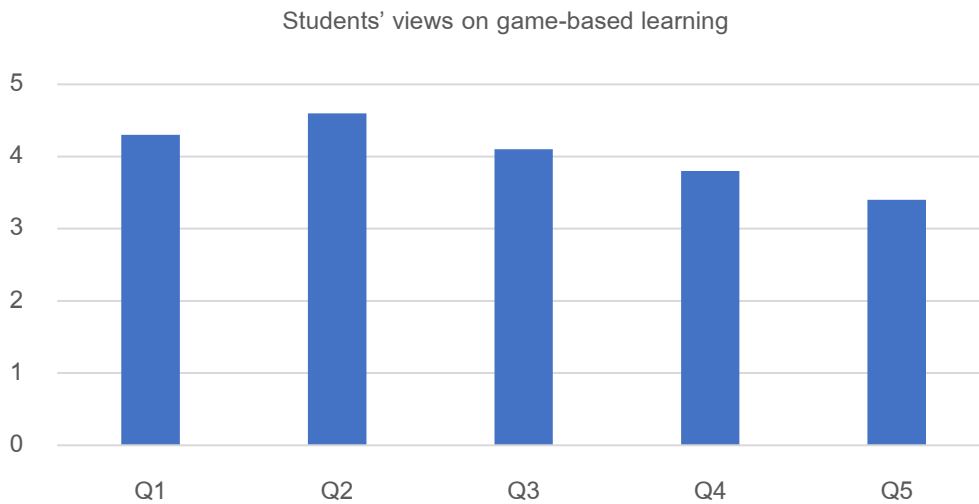


Figure 2 Students' views on game learning Xi

As it can be seen from the figure, students generally have a positive view of game learning, and their evaluation are all above 3.

Results of student Xi satisfaction analysis

In order to understand how students, feel after using this game learning and software, we have conducted a satisfactory analysis, and the results are shown in Figure 3.

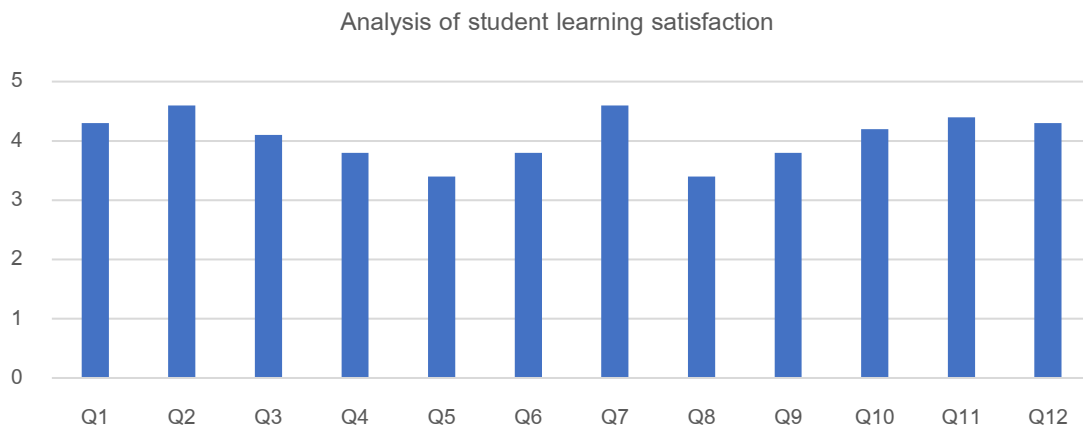


Figure 3 Analysis results of student Xi satisfaction

As we can see from Figure 3, students' learning satisfaction level with this software is very high, and its evaluation are all above 3.

Qualitative analysis results

In the game-based teaching/learning, students can also experience the key points that can be easily expressed. Instead of one lecture, the students are very satisfied with the feedback shown below in the questionnaire:

(Student No. 003)

In the past, I didn't understand how much the downstream sales volume affected the entire system, but now I know that a small change may cause a big change in the entire system.

(Student No. 009)

The teacher talked about the bullwhip effect in class for a long time, and I didn't expect that when we played online, I understood everything.

(Student No. 011)

This class is not boring at all, due to the experience of a close-to-a-real-world game, and it is amazing to let us know all the supply chain principles that are not easy to understand through one game.

Conclusion

In this study, we have recruited a department of marketing and supply chain management students to conduct the actual experiencing experiment. Where we find out that the Beer Game explores how its educational purpose of utilizing games to apply in today's business environment, to optimize the learning of supply chains, enhance collaboration, and improve overall performance. This game demonstrates the challenges of how to properly manage inventory and fluctuating demand. While we understand the bullwhip effect now, what should pay attention to avoid, and carefully to calculate the needs of the marketplace?

Therefore, by knowing the real-world experience, we should be considering the bullwhip effect while placing the order in the beer distribution system. Warning the participants when taking on the roles of retailers, wholesalers, distributors, and breweries.

The results demonstrated the students had a positive attitude towards the game teaching, and the teachers also had a positive attitude towards the gamification teaching evaluation of the game teaching system, and the results of the satisfaction analysis of the students' actual operation also showed that the beer game delivery system could make the students more thoughtful when they are facing a decision.

Besides the quantitative analysis showing that the system can meet the requirements of game simulation, the results of qualitative analysis also show that students can easily understand the things that were not easy to understand in the past through the process of playing game-based simulation. Therefore, it is suggested that schools with relevant courses in the future can make good use of this game teaching system to provide students with Xi learning results.

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