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Teaching the Bullwhip Effect through the Online Beer Game: A Practical Approach to Supply Chain Dynamics

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Abstract

Understanding the bullwhip effect is essential for managing modern supply chains, where small fluctuations in consumer demand can lead to amplified distortions upstream. This paper presents the use of the online Beer Game (https://beergame.masystem.se) as an interactive educational tool to simulate and analyze the bullwhip effect. In this web-based version of the game, students take on roles in a four-stage supply chain—retailer, wholesaler, distributor, and manufacturer—each making decisions based on limited local information. The simulation illustrates the impact of lead times, demand variability, and communication gaps on inventory levels and total supply chain costs. Players experience firsthand how uncoordinated decisions lead to excessive stock or shortages, reinforcing the need for information sharing and demand forecasting. The game provides real-time graphical results, supporting post-game analysis and comparison of strategies. This engaging approach effectively supports logistics and operations management education by transforming theoretical concepts into experiential learning.

Keywords
Bullwhip Effect, Supply Chain, Simulation, Beer Game and Logistics Education.

1. Introduction
Efficient supply chain management is a major challenge faced by companies, as they need to deal with unstable scenarios that present high demand variability. The bullwhip effect describes how small fluctuations in demand from the end consumer can cause large variations in orders made to suppliers and how this affects everyone involved in the supply chain, causing negative impacts on the organizations' inventory levels and costs.

The Beer Game, originally developed by MIT (Massachusetts Institute of Technology), provides practical experience on the dynamics faced by different links in the supply chain. Through the game, it is possible to simulate the flow of orders and products in a chain composed of retailers, wholesalers, distributors and the factory. During the study carried out, it was decided to use the digital version of the Beer Game (https://beergame.masystem.se), since the digital version

allows for the control of variables and the collection of data in an automated manner, making the experience even more interesting for students.

By using the online version of the "Beer Game" it became possible for students to experience the effects that individual decisions are capable of causing in a supply chain as a whole and how the bullwhip effect occurs in practice. In addition, students were able to understand in a practical way the importance of communication between the links in the chain.

This research was motivated by the growing need to prepare production engineering students to deal with systemic problems in the supply chain, in addition to seeking to offer a better understanding of the subject, engaging students and allowing practical learning on the subject. The Beer Game was used as a powerful educational tool capable of teaching through practice.

The problem addressed in this study is related to the difficulty faced by students in understanding the bullwhip effect based only on expository classes. Thus, through the use of gamification, through the online Beer Game, it is possible to observe how students react to scenarios that reproduce real problems.

1.1 Objectives

The general objective of this study is to provide production engineering students with a practical and realistic experience on the occurrence of the bullwhip effect, through the Beer Game Online game.

And the specific objectives are:

a) To evaluate the use of digital simulation through the Beer Game online as a teaching strategy for the bullwhip effect;
b) To analyze the data generated during the Beer Game simulation to identify important patterns;
c) To reflect on the lessons learned and their impact on the training of production engineering students;

2. Literature Review

Araújo and Oliveira (2025) define Supply Chain Management as the process that seeks to strategically manage the flows of goods, services, finances and information between companies involved, ranging from the manufacture of a product to the delivery of the product to the end consumer, seeking to achieve competitive advantages and create value for customers.

When seeking strategies to define stocks and production, companies can use demand forecasting, but even the most assertive forecasts can present errors that could compromise product deliveries. Therefore, one of the ways to reduce this risk is to base forecasts on the point of view of end customer consumption. For this to be possible, collaboration between all members of the supply chain is necessary (Coimbra and Xavier 2025).

Filho (2011) comments that within a supply chain, all members are responsible for making their demand forecasts and that this includes a certain level of uncertainty, which is called demand variability.

According to Coimbra and Xavier (2025), among the problems that can be found in a supply chain, those related to the so-called "Bullwhip Effect" are considered the most challenging, since they negatively influence all sectors involved in the chain and even harm the relationship between sectors. Therefore, organizations need to find ways to reduce the impacts between production and demand, seeking to guarantee the supply of all the chain.

The Bullwhip Effect is the name given to a problem that is directly linked to the supply chain, and it occurs when there is an increase or decrease in demand for a given product (Araújo and Oliveira 2025)

Brandão and Filho (2020) explain based on their research that the bullwhip effect is related to the distortion of information, going from the end of the supply chain to the primary supplier, where small variations in demand are capable of generating large impacts that result in excessive stocks in all participants in the supply chain.

Coimbra and Xavier (2025) state that the propagation of information errors within a supply chain is usually responsible for the bullwhip effect. The authors cite a study that took place at MIT (Massachusetts Institute of Technology) in

1958 as being the oldest study in the area. This study sought to understand the effects of increased errors caused by incorrect information about demand information, which generated an adjustment in the inventory level, but which ultimately caused disturbances in the chain links, since it was different from the distributor's demand, for example. In this way, the quantity in stock present in the factory ended up being very different from the distributor's quantity, which also differs from the other levels involved in the chain. Furthermore, the study shows that the greater the number of people involved in the chain and the further away it is from the final demand, the greater the value of the variations, which generates extremely negative impacts for everyone involved, generating larger inventories than necessary and impacting various costs for the company.

Paccola et al. (2014) explain that due to constant technological advances, universities need to improve their teaching and learning methods in order to provide better preparation for their students. In addition, the authors also report that engineering education needs to advance to provide students with practical experience of the real world, where the traditional teaching model must be revised in search of dynamic teaching with a focus on student learning.

Sartori et al. (2021) state that teaching through simulations has been used as an alternative to highly theoretical classes in higher education institutions (HEIs), which provides students with the experience of situations that occur in the real world, allowing problems that are faced in companies to be replicated within the classroom, allowing students to seek solutions, developing a systemic view of problem-solving.

Paccola et al. (2014) corroborate that playful games that simulate real-life situations in engineering have proven to be very effective in assisting students in the teaching-learning process.

Kampff and Silva (2020) state that gamification has emerged as a trend in the development of skills and abilities.

Sartori et al. (2021) show a proposal for the use of simulation to teach subjects related to the supply chain, through a game called “Easter Game” that allows students to send orders to suppliers without knowing the information of the other participants in the supply chain, quickly causing the bullwhip effect, allowing students to understand the bullwhip effect in a practical way through simulation.

Kampff and Silva (2020) explain that the Beer Game is a game that simulates the behavior of a supply chain, where it is possible to observe the fluctuation of market demand. The authors report that the challenge in the Beer Game is to maintain a balance between orders made by customers to meet consumer demand and at the same time not fail to meet orders, maintaining the smallest possible amount of stock.

After applying the Beer Game to a specific class, Kampff and Silva (2020) concluded that the game requires students to have skills such as controlling operating costs, managing inventory, and good communication. In addition, the authors report that it was possible to observe that these gamified activities proved to be promising for the development of pedagogical skills, relating theory to practice.

Souza et al. (2019) conclude from their studies that higher education institutions need to include active methodologies in their courses, and that the use of business games, such as the Beer Game, is still little used, even though it contributes to improving the teaching-learning process.

3. Methods

The methodology used in this study is exploratory in nature, using a qualitative approach, seeking to analyze the use of the Beer Game Online as a teaching-learning strategy for the topic of the bullwhip effect, for production engineering students, during classes in the Supply Chain discipline.

Groups of 4 students were formed, where each one assumed the role of a link in the supply chain, being: 1 retailer, 1 wholesaler, 1 distributor and 1 factory. The Beer Game took place through the platform https://beergame.masystem.se and was structured in the following classes:

a) Class 01 – August 20, 2024
• Initially, the rules of the game and the initial concepts about the bullwhip effect were presented;
• The students carried out the simulation of the Beer Game, allowing them to familiarize themselves with the game and carry out multiple rounds of decision-making.

b) Class 02 – August 27, 2024
• The students resumed the game and carried out several rounds of the Beer Game simulation;
• At the end of the day, the students sent their results obtained through a printout with the best costs obtained and described the strategy used to reduce costs.

c) Class 03 – September 03, 2024
• The students carried out new rounds of the Beer Game, with the objective of being able to better apply the concepts related to the topic, since in this class they were already more familiar with the game;
• At the end, they prepared a report with the results of the best costs obtained and answered the following essay questions:

1) Using the technologies available on the market, how would the group suggest an improvement in the flow so that the bullwhip effect is minimized?

2) Describe the strategy used by the group to reduce the bullwhip effect.

d) Day 04 – September 10, 2024
• Individually, to conclude the subject in a structured manner, based on the knowledge acquired in the classroom and through practical experimentation in the "Beer Game", students must answer the following questions related to the Bullwhip Effect:

1) Which of the following strategies can help mitigate the bullwhip effect?
( ) Encourage purchases in large batches.
( ) Maintain high levels of safety stock.
( ) Increase lead time.
( ) Implement a shared information system.

2) What is the bullwhip effect in the supply chain?
( ) Fluctuation in demand from end consumers.
( ) Increasing variation in orders along the supply chain.
( ) Increased logistics efficiency among suppliers.
( ) Reduction in inventory along the production chain.

3) Which of the alternatives below is NOT a consequence of the bullwhip effect?
( ) Excessive stocks at some stages of the chain.
( ) Greater accuracy in demand forecasting.
( ) Stockouts at points of sale.
( ) Increased storage costs.

4) The practice of "batch orders" contributes to the bullwhip effect because:
( ) It reduces transportation costs between links in the chain.
( ) It increases production efficiency.
( ) It causes greater variations in order levels.
( ) It reduces demand variability.

5) How does lead time influence the bullwhip effect?
( ) Longer lead times amplify the bullwhip effect.
( ) Lead times have no impact on the bullwhip effect.
( ) Longer lead times reduce the bullwhip effect.
( ) Shorter lead times amplify the bullwhip effect.

6) How can volume discounts influence the bullwhip effect?
( ) It reduces demand variability.
( ) Causes fluctuations in orders along the chain.
( ) Reduces logistics costs and the bullwhip effect.

( ) Encourages real consumer demand.

7) Which tool or methodology can help minimize the bullwhip effect in the supply chain?
( ) Total Quality Management (TQM)
( ) Demand forecast based exclusively on sales history.
( ) Just-in-Time (JIT) system.
( ) Supply chain without data sharing.

8) Which of the following is a common cause of the bullwhip effect?
( ) Bulk purchases.
( ) Lack of safety stock.
( ) Reduction in lead times.
( ) Accurate demand forecasts.

9) The bullwhip effect tends to be most visible in which part of the supply chain?
( ) At the end consumer's end.
( ) At the beginning of the chain, between raw material suppliers.
( ) In distribution between logistics centers.
( ) It is not visible anywhere in the chain.

10) What generally causes increased fluctuations in orders along the supply chain in the bullwhip effect?
( ) Implementation of Just-in-Time (JIT).
( ) Reduction in production costs.
( ) Accuracy in demand forecasts.
( ) Misalignment between supply and demand.

These questions allowed us to assess whether the teaching-learning process through the online Beer Game was effective.

4. Data Collection

Data collection occurred in two ways. The first was automatically through the Beer Game Online platform itself, where students had access to the results obtained in each round. The second method, and more relevant in this case, was through reports sent by students in classes on August 27, 2024, and September 3, 2024, in addition to the questionnaire answered on September 10, 2024, where each student individually answered 10 questions related to the topic, which allowed the students' learning to be measured.

5. Results and Discussion

5.1 Numerical Results

In order to evaluate the effectiveness of using the Beer Game Online as a teaching-learning strategy, a questionnaire with 10 objective questions was applied on September 10, 2024, as detailed in the methods section of this article. The questionnaire addressed concepts considered fundamental related to the bullwhip effect and supply chain that were worked on through the beer game and, through the analysis of the questionnaire results, it was possible to verify the level of understanding of the students after experiencing the practical activity.

A total of 33 production engineering students answered the questionnaire and the results demonstrated high student performance, where the average score was 9.36 points, with a standard deviation of 1.15 points, which shows that there was a high concentration of correct answers among the students and a low dispersion of the results. Table 1 shows the distribution of students' grades:

Table 1. Distribution of students' grades

STUDANT	POINTS
Student 1	10
Student 2	10
Student 3	10
Student 4	10
Student 5	10
Student 6	9
Student 7	10
Student 8	10
Student 9	8
Student 10	10
Student 11	10
Student 12	9
Student 13	10
Student 14	9
Student 15	10
Student 16	9
Student 17	10
Student 18	6
Student 19	10
Student 20	10
Student 21	9
Student 22	10
Student 23	9
Student 24	10
Student 25	10
Student 26	9
Student 27	9
Student 28	10
Student 29	5
Student 30	10
Student 31	8
Student 32	10
Student 33	10

By analyzing the table, it is possible to observe that most students obtained grades equal to or greater than 9, in addition, 21 students stood out who obtained a grade of 10 (maximum grade). Only two students obtained grades less than or equal to 6, demonstrating that the use of the online Beer Game contributed significantly to the understanding of concepts related to the bullwhip effect in supply chains.

5.2 Graphical Results

Figure 1 shows the individual grades of the 33 students who participated in this study. It is possible to observe a high concentration of maximum grades, and it is also possible to observe a homogeneous performance of the class, where few students had a score lower than 9, which reinforces the information presented in 5.1 of this article.

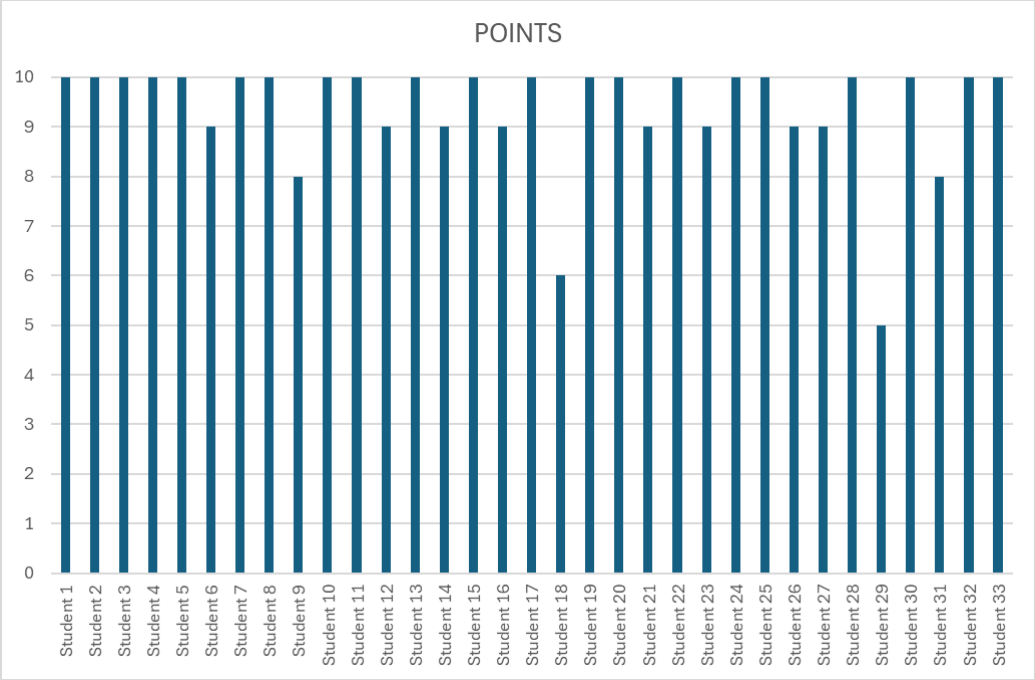

Figure 1. Individual grades of the students

When analyzing the graph presented in Figure 1, it can be observed that there was a low dispersion of the results, which was proven by the graph presented below, in Figure 2:

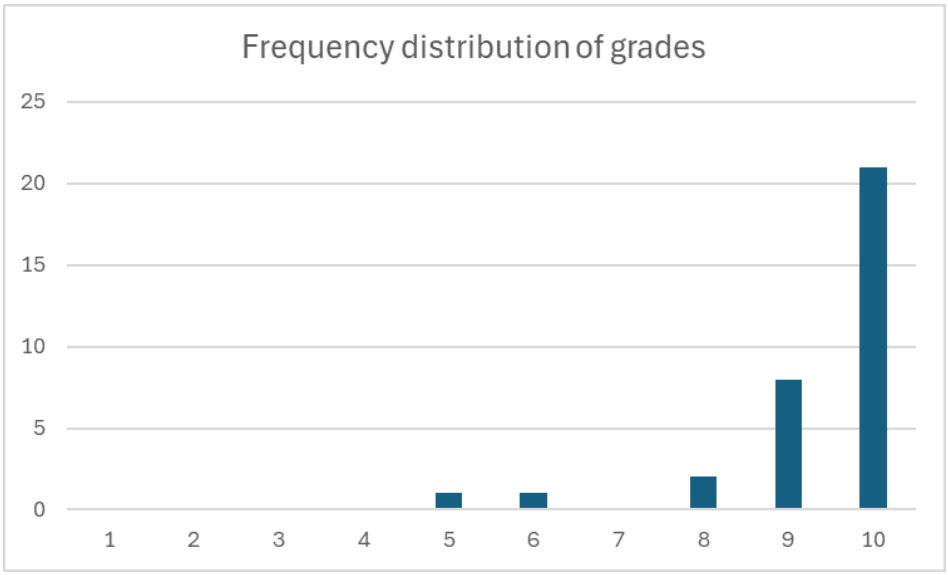

Figure 2. Frequency distribution of grades

The graph shown in Figure 2 shows the frequency distribution of the grades obtained by the students. Once again, it is possible to prove that the highest grade was the most frequent, being recorded by more than 60% of the class. Thus, through this graph, it is possible to clearly demonstrate the tendency for high grades to be concentrated, which confirms that most students showed an excellent understanding of the concepts worked on through the Beer Game Online.

The data collected confirm that the use of the Beer Game as a teaching-learning tool is effective, validating this adopted strategy.

5.3 Proposed Improvements

Based on the results obtained and the observations made during the activity, some opportunities for improvements in the use of the Beer Game as a teaching-learning strategy were identified:

a) Improvement of the theoretical introduction, allocating more class time to the concepts before beginning the practical application of the Beer Game;
b) Carry out a comparison between the application of the Beer Game with and without communication, in different rounds, so that students can compare the behavior of the supply chain and understand, in practice, the impact of communication.

5.4 Validation

As validation of the study carried out, we can highlight the analysis of the students' performance in the questionnaire that was applied at the end of the application of the Beer Game as a teaching-learning strategy, and also by the observations that were made in the classroom.
The high grade of the students indicates that the objectives were achieved satisfactorily. In addition, the active participation of the students during the Beer Game rounds, the discussions that took place at the end of the activity demonstrated high acceptance by the students.
This combination of the good results obtained in the questionnaire, with the engagement observed in the classroom represents a practical validation of the effectiveness of using the Beer Game as a teaching strategy. For future studies, it is recommended to complement the analysis with other qualitative and quantitative instruments, in order to broaden the understanding of the impact of using the beer game on the students' learning process.

6. Conclusion

The use of the Beer Game Online as a teaching-learning strategy for the topic Bullwhip Effect within the Supply Chain discipline for production engineering students proved to be highly effective in promoting understanding of the concepts covered, since through the game, students experienced the problems present within the supply chain in a practical and interactive way.

The grades obtained in the questionnaire that the students answered demonstrated a high level of assimilation of the content, with an average performance of 9.36. In addition, during the classes in which the Beer Game was applied, a high rate of engagement and active participation of the students was noted, reinforcing their high acceptance.

This experience provided students with the development of hard and soft skills, such as teamwork and communication, which are essential skills for production engineers working in the supply chain area.

As a suggestion for future work, it is recommended to carry out a round of the Beer Game without allowing communication between the participants, allowing them to experience in practice how the lack of communication can further affect the participants in the supply chain.

The use of Beer Game Online proved to be a valuable tool for teaching the topic of the bullwhip effect, bringing theory closer to real life and making the teaching-learning process more meaningful and engaging for the student.

References

Araújo, A. and Oliveira, V., *Bullwhip effect in the supply chain: A study in a transportation company*, *Proceedings of the EnGeTec Conference*, São Paulo, Brazil, 2020. Available: https://www.fateczl.edu.br/engetec/engetec_2020/3_ENGETEC_paper_74.pdf

Brandão, M. and Filho, M., *Occurrence and causes of the bullwhip effect in the supply chain of luxury products*, Revista de Administração de Roraima, vol. 10, no. 1, 2020. Available: https://dialnet.unirioja.es/servlet/articulo?codigo=8077746

Coimbra, A. and Xavier, D., *How the bullwhip effect impacts demand forecasting in supply chain management*, Proceedings of the EnGeTec Conference, São Paulo, Brazil, 2022. Available: https://www.fateczl.edu.br/engetec/engetec_2022/5_EnGeTec_paper_180.pdf

Filho, J., *Trust*, *Commitment, and bullwhip effect in automotive supply chain management,* Master's thesis, University of São Caetano do Sul, São Caetano do Sul, Brazil, 2011. Available: https://repositorio.uscs.edu.br/server/api/core/bitstreams/3838f827-b7fd-4b49-ae47-798af7fe11b4/content

Paccola, F. et al., *The boat game: An innovative version including value stream mapping*, Proceedings of the COBENGE Conference, Brazil, 2014. Available: https://www.abenge.org.br/cobenge/legado/arquivos/5/Artigos/129083.pdf

Sartori, A., et al., *Interdisciplinary teaching-learning practice simulating the bullwhip effect in a supply chain,* Proceedings of the EnGeTec Conference, São Paulo, Brazil, 2021.

Silva, R. and Kampff, A., *Gamification as a pedagogical strategy in professional education*, Revista Brasileira de Educação em Ciências e Matemática, 2020. Available: https://seer.upf.br/index.php/rbecm/article/view/10283/114115460

Souza, M. C., Franco, M. L., Souza, A. O., Novais, A. F. O. and Marquez, J. A. R., *Beer game: Business game as a method of learning in higher education,* Brazilian Journal of Development, vol. 5, no. 12, pp. 31865-31879, December 2019. Available: https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/5568/5050

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