Design of a serious game simulation for learning supply chain management

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Abstract Demonstrating concepts in a practical way is considered as more powerful and effective than purely explaining the underlying theory. This paper presents a new business game named SIMOP which helps to understand concepts developed in logistics and supply chain management classes. The game provides insights into different aspects of supply chain, i.e., the bullwhip effect, production, transport, customer services, inventory, the decision-making process as their trade-offs. This allows for people who have no deep notion in this area to better understand its concepts and improve their knowledge in practice. The paper describes game rules, playing process and future directions.

Keywords: Serious game, Simulation, Supply chain, Education;

1 Introduction

The dynamics, connectivity and competitiveness present in the business environment caused by technological advances put pressure on supply chains to become increasingly efficient. The search for efficiency encompassing the insertion of new technologies and the improvement in managerial decision making.

One of the definitions presented in Alvarez's work [1] suggests that a serious game is a tool, computational or not, that aims to improve the teaching of a given subject. This characteristic made such games very widespread in the business and academic environment. [2] Especially in American educational institutions in the business field.

Combining these aspects, many games were developed to simulate the peculiarities of the supply chain. Since the bullwhip effect presented in the famous Beer Game, the New ORSIAM Int 'dealing with decision making management [4], the Log_Dis Supply Chain game introduces the concepts of a dynamic system [5] among other infinities of games.

However, researchers in the field, often do not enjoy great knowledge about programming, have made most of the supply chain simulation games developed to be rudimentary, conceptually specific and technologically limited.

The objective of this research is to develop and present an innovative, flexible, robust and free serious game that simulates the supply chain. The idea is to include aspects that other games have not yet addressed and make it available to the entire academic community.
2 Serious games

In general, the definition of the term “serious game” is not yet well defined. But it can be understood as the application of games for the purpose of learning [6] with the greatest contribution to experiential learning. The potential provided by serious games is already accepted and introduced in several academic courses, such as medicine, economics and engineering [7]. Because of a simulation, the application of a serious game allows players to improve their decision making without having a real risk associated [8,9]. But these games are not only applied by the academy. Companies such as: IBM, L’Oréal and Thales Group developed specific games for certain problems faced by their management, applied the games and collected valuable information that contributed to solving real problems [10].

The most common platforms for these games are boards, spreadsheets, cards and software. Each platform has its advantages and disadvantages. For example, although the software allows scalability, automation, ease of mathematical resources, mobility and greater gameplay, programming knowledge is required and generally involves high costs for implementation. In addition, manual games (boards, spreadsheets and cards), even allowing greater replicability and low cost for application, require greater coordination, manual tasks and need a physical space to be applied [11,12].

3 Methodology

The methodological processes applied in the research are divided into 3 stages.

3.1 Bibliometric analysis

The sample space of bibliometric research was limited to searching the Web of Science database. The idea was to filter the articles that dealt with this field of interest. Bibliometric analysis consisted of a number of publications over the years, countries, institutions and most relevant journals, co-authorship, co-occurrence, co-citation, citations and bibliographic coupling. The complete process of bibliometric analysis can be consulted at [13].

3.2 Analysis of existing games

Based on a filtering of works that contained the keywords “supply chain” AND “Game” OR “Gamification” OR “Gaming”, we sought to limit the selection of works on the theme focused on computational interfaces. At the end of this stage, 15 games were collected, from the academic works mentioned. After the games were identified, four pillars supported the evaluation of the games, they were: their computational characteristics; set of activities related to the chain; limitations and chain links considered in the games. Tables were constructed to summarize the findings. The complete process for analyzing the games listed can be found at [14].

3.3 Elaboration of the Game

For the development of the new serious game, a sample of 15 existing games was analyzed to assist the learning process. From the limitations of these games, the configurations of the new serious game SIMOP were modeled.
4 SIMOP Game

The SIMOP game was developed in the Java language, with the production of reports using Jasper Report. This company game simulates a supply chain to produce shoes. Seeking to cover 3 of the 4 areas of strategic logistics planning: Customer services; Inventories and Transport. The location area is not directly treated, but it is represented in the game by the times and costs involved in the displacement, be it raw material or finished products. To be able to attend these three areas, the player must exercise the activities and processes that support them according to the rules described below.

With the purpose of assisting learning related to supply chain management, the game works in a simulated environment where, throughout the rounds, demands are generated which the teams of players need to manipulate the entire supply chain in order for distributors (final link in the chain) are able to meet them in a timely manner. The competitiveness of the game is given by the search for better strategies that enable greater profitability for each company and customer satisfaction. When starting the game and logging in, the team / player will encounter Figure 1.

On this home screen you will find the tools menu and a chart of indicators. As indicators are present the graphs about the company's capital, the goods in stock in the factory's warehouses and the last productions made. Clicking on “Data Flow”, the panel according to Figure 2 is displayed.

![Fig. 1 Initial screen](image-url)
On this home screen you will find the tools menu and a chart of indicators. As indicators are present the graphs about the company's capital, the goods in stock in the factory's warehouses and the last productions made. Clicking on “Data Flow”, the panel according to Figure 2 is displayed.

This panel contains all the elements of the supply chain to be worked on. From left to right we have the supplier, supply warehouse, factory, factory warehouse, distribution warehouse and distributor (company). Transport configurations are present among all links in the chain, except for the factory warehouse. In addition, the administrator can also vary the structure of the supply chain as he wishes, for example, by adding or decreasing supplier options, the number of warehouses, transportation options, etc. This feature makes it possible to develop stages of difficulty in the game and to further explore players' decision making. Which has a fundamental role in improving their knowledge. The dependent and independent variables present in the game are summarized in Table 1 below.

Table 1 Variables present in SIMOP

<table>
<thead>
<tr>
<th>Link / Variables</th>
<th>Independent</th>
<th>Dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier</td>
<td>Type of raw material, Quantity of material available and Status.</td>
<td>Supply cost.</td>
</tr>
<tr>
<td>Transport</td>
<td>Destiny, Quantity to be transported and Modal.</td>
<td>Delivery time and Cost of freight.</td>
</tr>
<tr>
<td>Warehouse</td>
<td>Quantity of raw material in stock, Daily fee and Insurance fee. Transformation time, Transformation cost, Transformation factor, Customer service fee, Research value and Demand (%).</td>
<td>Storage cost. Quantity of raw material available, Production order and manufacturing cost.</td>
</tr>
<tr>
<td>Factory</td>
<td>Cost price.</td>
<td>Quantity of product stocked, Sales price and billing.</td>
</tr>
<tr>
<td>Distributor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
It should be noted that the game administrator has control over all game variables, which allows the administrator to maintain the constant presence of uncertainties in the chain. In addition, other issues need to be taken into account in decision making. They are: the average, variance, seasonality and trend of demand established in each round; information on the minimum load required to use each modal (rail, waterway and road); investment decisions (improvement, advertising, environmental policy or research) that, when judged by the administrator, can provide an advantage in the game; follow a proportion of raw materials in the footwear production order (60% plastic and 40% leather) and control over the time available until the round is closed (after closed, players are unable to make any changes to the chain).

The application of the game can take place both in person and virtually. Because, thanks to the database inserted in the game, it allows the remote communication of the players to the administrator and between the players themselves. Via the communication window programmed in the game (Figure 3). In addition, the robustness of the game is significant since it will not be limited to a small number of teams or players.

At the end of the rounds, both the players and the administrator can consult reports made available in the game to analyze the financial situation of each company, check the registered players, decisions about production and data per round. Below are examples of data reports for a given round (Figure 4) and the financial situation of a company created (Figure 5).

In figure 6, a general model of the decisions to be applied by the player is presented. Emphasizing the possibility for the administrator to change the information at the end of each round.
As can be seen, the player / team will assume the role of all the links represented in the chain. In formulating demand forecasting strategies, players can seek mathematical forecasting models to assist them. In addition, several tools and techniques from the operational research area can facilitate decision making. The characteristics that make SIMOP stand out from the other identified games are:

- The high flexibility of the chain. Because the administrator has total control over the number of suppliers, factories, number of raw materials and so on. Allowing the creation of multiple chain configurations;
- The robustness of the programming also makes it more positive. Because the software, next to the database, allows an almost unlimited number of participants, remote access to the game via the network and full communication between members of the game via messaging services;
- In the theoretical framework involved, SIMOP encompassed the areas of Customer Services; Inventories and Transport;
Another point is the function of obtaining more information in the game at the cost of an amount of your billing provided by the administrator via the “Research value” and the efficiency function of the production process via the “Transformation factor”, variables present in the link from factory;

Finally, SIMOP guarantees the requirement to evolve the level of complexity / difficulty required in teaching games. In it, the administrator can configure from the simplest to the most complex supply chain.

5 Conclusions

In this work, a survey and evaluation of companies' games focused on the supply chain was carried out. SIMOP is a computer-based educational game, in which students play the role of suppliers, warehouses, factories and distributors. Being web-based, the game can be played remotely. The main characteristics that set it apart from the other games analyzed are greater flexibility, more robust programming, encompassing the areas of customer service, inventory and transport and allowing the gradual advance of difficulty during rounds. The limitations of this work are concentrated in the sample of games analyzed. For extensions of this work, the validation / measurement of the contribution provided by the SIMOP game to the teaching-learning process of the main processes that occur in a supply chain will be performed. For this, it will be necessary to build a questionnaire to obtain data from the participants, apply the game to an adequate sample of students and, finally, statistically evaluate the data collected. As a result of this project, it is intended to make the presented game available for free so that the entire academic / business community can enjoy its use.

6 Acknowledgement

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References


