Designing and Evaluating a Business Simulator for Sustainable Logistics Decisions

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Abstract

Some studies have shown that a good portion of businesses fail because of the owner’s inexperience dealing with administrative issues, financial conflicts, lack of planning and bad decisions in the production stage. Making for these business hard to find sustainable business practices involving Economics, Social and environmental factors. The use of business simulators (BS) or games is a good practice to avoid this, testing business strategies and their change effect. BS are regularly based on virtual simulation games aimed to students and providing entrepreneurs a first contact with the business world while allowing them to make decisions without the risks that this entails in reality. A BS is then perceived as a fun learning opportunity tool for playback an economic, financial and / or business system.

We took on the task of designing and implementing a simulator with these characteristics. We decided to initially test the simulator with two groups of students of the course “Inventory Management” in order to measure four social variables such as variables: interest, ease of use, preference for simulators and learning.

Keywords
Education Simulators, Business Simulators, Sustainable Practices, Economic Analysis, Inventory Control, Logistics Supply Chain Management, Value Chain.
**Background.**
Some studies have shown that a good portion of businesses fail because of owner’s inexperience dealing with administrative issues, financial conflicts, lack of planning and bad decisions in the production stage. Pimenta (2004) states that a good practice to avoid this, is the use of business simulators (BS) or games to test business strategies and create change. BS are regularly based on a virtual simulation game aimed to provide students and entrepreneurs with a first contact with the business world and allow them the opportunity to make decisions without the risks that this entails in reality. A BS is then perceived as a fun learning tool that aims playback economic, financial and / or business system.
The BS serve as support to help people experience a business environment by making their own decisions, which involves the administration of a company or business, being able to know immediately the consequences of decisions which are generated in terms of results, strategy and market positioning.
Pimenta (2004) adds that the experience of such games in “working with companies” operate as "a kind of laboratory," where you can try and experiment with different strategies and decisions to evaluate the results of these actions. He concludes that in the same way that physicists, chemists and biologists perform experiments in laboratories, executives can use these games and their “companies” to reflect strategies on a particular topic.

In the market there is no BS focused on making logistics decisions for Industrial Engineers, so we took on the task of designing and implementing a simulator with characteristics that may be of help for these students. When the simulator (BS) was prepared, we decided to put the simulator to test with two groups of students studying the subject of “Inventory Management” in an effort to measure social variables such as interest, ease, learning and preference. Once the results would be obtained they were to be used to confirm the effectiveness of the tool and if necessary, adjustments should be made to the program, to improve the ease to use it by the students enrolled in the aforementioned matter. The focus of the research was: “What is the perception regarding: interest, ease of use, learning and preference for simulator?”

**Independent Variable: Interest, easily, learning and preference**

**Dependent Variable: Perception**

**Research Objectives**
This study was aimed to design a tool for student’s learning through a business simulator and making sustainable logistical decisions and measure perceptions through four inclusive variables which are: interest, ease of use, learning and preference for simulators.

**Game Development**
The Business Simulator for Logistics Decision Making or “Simulador de Negocios para la toma de Decisiones Logísticas” (from now on referred to as SNTDL due to its capital letters in Spanish) was tested with two groups of students studying the subject of "Inventory Management" the area of Engineering and Architecture of the Tecnologico de Monterrey, Campus Ciudad de Mexico, during the months of October-and November of 2013 . The game allows the simulation for decision- making in virtual logistics where the student has the opportunity to put into practice what they learned within their academic experience and therefore strengthen their learning. Once the simulator was used for 2 months in the two groups, each student was asked to answer a simple survey, with no particular statistical design but just to have a first glance at the perception of the users.

**Materials**
For the development of the gaming version for laptop, Windows 7 operating system and Microsoft Office Excel 2007 software was used, basically due to the automation programming language of Microsoft VBA ( acronym in English for Visual Basic for Applications) integrated in Microsoft Office applications .

**Simulator Properties**
Taken from the literature review and the prospected game objectives, we have the following list of the features required for the game, and the decisions derived from the management of such resources which are presented below:
- 8 different items to produce.
- 3 machines for the production of articles.
- 3 raw materials needed for production, through three different providers for each. (a total of 9 providers)
- A demand history of the previous 4 years.
- Times required per machine for each item are provided, and the necessary raw materials as well as the selling price.
• A cost counting feature, product quality (as a percentage), delay time (weekly) and fixed costs to order items (transportation costs) for each of the suppliers.
• An initial raw material inventory.
• The Initial capital of $100,000.00 (one hundred thousand dollars) was assigned into a bank account, which offers an annual interest rate of 8%.
• Product Quality requires a minimum acceptance rate of 90% per week.
• Each player is to take decisions weekly for one year (52 weeks).

Generation demands
In order to reflect real life situations in the game similar, the demand presents variability, normal distribution or uniform distribution, seasonality (which uses a sinusoidal cycles of high, medium and low demand), and a percentage of decrease / increase for the simulated period. Note that the above-mentioned parameters can be freely modified by the instructor (prior to the start of the game) in the table presented below. This table is not visible to the players.

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Normal</th>
<th>Normal</th>
<th>Normal</th>
<th>Uniform</th>
<th>Uniform</th>
<th>Uniform</th>
<th>Uniform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>μ</td>
<td>μ</td>
<td>μ</td>
<td>a</td>
<td>a</td>
<td>μ</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>σ</td>
<td>σ</td>
<td>σ</td>
<td>b</td>
<td>b</td>
<td>σ</td>
<td>b</td>
</tr>
</tbody>
</table>

| Number of cycles per year | 200  |
| Sensitivity to the station | 60   |
| Random (for cycle start)    | 0    |
| Percent increase on demand | 50   |

Figure 1. Demand generation parameters.

In order to observe the behavior of the demands from the change of its parameters, examples with normal and uniform distributions are presented:

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>200</td>
</tr>
<tr>
<td>Number of cycles per year</td>
<td>0</td>
</tr>
<tr>
<td>Sensitivity to the station</td>
<td>50</td>
</tr>
<tr>
<td>Random (for cycle start)</td>
<td>3.4382</td>
</tr>
<tr>
<td>Percent increase on demand</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>320</td>
</tr>
<tr>
<td>Number of cycles per year</td>
<td>30</td>
</tr>
<tr>
<td>Sensitivity to the station</td>
<td>2</td>
</tr>
<tr>
<td>Random (for cycle start)</td>
<td>0.2074</td>
</tr>
<tr>
<td>Percent increase on demand</td>
<td>3</td>
</tr>
</tbody>
</table>
Figure 2. Normally distributed demand variation.

Figure 3. Demand Changes for uniform distribution.
Game Interface
At the beginning of the game, the player is asked to take a role of logistics manager of a company, in order to analyze the information provided to them and carry out the decisions respectively. The window that is presented to the user to enter the game for the first time is shown in Figure 4.

It is noteworthy that for the game to work correctly, the player must enable content "macros". To do so, students must follow the procedures specified as a post-title program "note" within the simulator.

Once the player completes reading the history of the company, he must press the "Click " button, in order to obtain more information which is shown in the following window (Figure 5):

DF Op (Operations Definition)
On the second tab the BS will display all the characteristics of operation for Mike's Armory, where players can observe the following information:
No Author 1, 2, or 3 Last Name Yet

Figure 6. General Features Screen.

- First block: machining times in minutes for each of the items, quantity of raw material for each of the items, sale price of each product, number of units at inventory, and the minimum percentage of accepted quality in a batch of production.
- Second block: Suppliers and their names, cost per kilogram of raw materials, product quality percentage, delay times, cost of delivery and number of kilograms at inventory.
- Third block: Quantity of money that you have invested, the rate of annual interest invested.
- Fourth block: Number of workers (regularly students must consider 2 workers per machine), the salary of each worker per week, and the operating cost per hour at each machine.

An important note is that you can change all the parameters and have different versions of the game. Even more, you could change the number of products, raw materials, machines and suppliers.
**Decisions Tab**

Here the user will carry out decisions for the length of the game in 52 periods. A window shows the decisions that the user should take (listed from top to bottom and left to right):

<table>
<thead>
<tr>
<th>Number of units at inventory</th>
<th>Product 1</th>
<th>Product 2</th>
<th>Product 3</th>
<th>Product 4</th>
<th>Product 5</th>
<th>Product 6</th>
<th>Product 7</th>
<th>Product 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>210</td>
<td>90</td>
<td>170</td>
<td>220</td>
<td>305</td>
<td>180</td>
<td>155</td>
<td></td>
</tr>
</tbody>
</table>

**Decision 1**

<table>
<thead>
<tr>
<th>Number of Kgs at inventory</th>
<th>Raw Material in transit</th>
<th>RM A1</th>
<th>RM A2</th>
<th>RM A3</th>
<th>RM B1</th>
<th>RM B2</th>
<th>RM B3</th>
<th>RM B4</th>
<th>RM C1</th>
<th>RM C2</th>
<th>RM C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>92</td>
<td>76</td>
<td>91</td>
<td>52</td>
<td>120</td>
<td>76</td>
<td>83</td>
<td>135</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Decision 2**

**Decision 3**

<table>
<thead>
<tr>
<th>Raw Material that you will use at the batch production</th>
<th>RM A1</th>
<th>RM A2</th>
<th>RM A3</th>
<th>RM B1</th>
<th>RM B2</th>
<th>RM B3</th>
<th>RM B4</th>
<th>RM C1</th>
<th>RM C2</th>
<th>RM C3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The amount of raw material that you are using is sufficient for the production run?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Error Handling**

If a player wants to move to the next period, the production run must meet the requirements:

- **Machining Time available**: It is considered that the machines have a period of 80 hours (16 hours of labor, 5 days a week).
- **Money**: It is necessary that the player has enough money to pay orders, the workers’ wages and the cost of the machines operations.
- **Raw Materials**: Users need to have enough raw materials to make the products specified at Decision 1.
- **Percentage of average product quality**: The player must have a minimum of quality. The quality is calculated as a weighted average according to the amount of raw material.

If there is an error, the player must modify the data entered.
Weekly Report
Once the player has entered all the decisions without errors, he/she will receive a pop-up window which displays the weekly summary shown below (Figure 8). Simultaneously, the tab is hidden with the current period and displays the tab with the following period.

![Figure 8. Pop-up Weekly Report.](image)

Final Report
Once the player completes 52 weeks of simulation, or runs out of funds in the bank, the game automatically displays the tab of the final report, hiding the tab for the final decision. The Final Report tab is shown below:

![Figure 9. End of Game screen.](image)

From the results of this report an evaluation is to be carried out for the player and group comparisons are possible, therefore best and worst performance can be identified, observed and analyzed and the strategies that produced such results.

Security
The simulator has two security features:
- VBA Code: Requires a password to access the VBA (Visual Basic for Applications) programming. This ensures that the player cannot change parts of the code or display tabs that are hidden throughout the game.
- Protection tabs: The tabs visible to the player are locked, so you are not allowed to edit formulas, format or items necessary for the proper functioning of the program. Players can only write into the relevant decision-
making cells and have available (not blocked) the sales history tab, in that way they can produce graphs or data analysis.

- Validity: The programmer has the possibility to enter a date (format: dd /mm /yyyy) of "expiration" of the file, that way the game will be available to the player only during the current semester for the assigned materials.
- AutoSave: All changes made are saved automatically in the simulator / game, by doing so players lose the chance to dishonestly change previous decisions in the program or to alter records, the weekly demands and other playing features.

**Implementation**

The game was tested with two groups of students studying the subject of “Inventory Management” taught by Dr. Ernesto Pacheco-Velazquez. Each student applied a survey to collect comments, observations and improvements that will be applied to the game.

**Changes in Version 2**

Experts of industrial engineering were consulted, in production knowledge areas to consider their opinion and comments about the game. From these comments the game was modified as follows:

- Sales history is displayed (replacing the deployment of demand history).
- Players can vary the selling price of the items, thereby generating changes in demand.
- Quality of raw materials affects the percentage of defective items.
- Delivery time for raw material is calculated according to a stochastic probability function.

This second version has not been tested yet by students, however, is already functional.

**Results and Conclusions**

The SNTDL was tested with two groups of students studying the subject of "Inventory Management" the area of Engineering and Architecture of the Tecnologico de Monterrey, Campus Ciudad de Mexico, by Dr. Ernesto Pacheco Velazquez during the October-November 2013. Once the simulator was used for 2 months in the study group, each student was applied a survey. Since there is no history in the institution of such games, the main interest of the study was to analyze the behavior and the interest of the students, the ease of using the simulator, the preference for the use of simulators versus reading cases, and the sense of learning as a result of playing the game.

In summary, from the analysis of results shown above, we can say that:

- The interest in the game by the students was high (i.e., it was a fun game and well received by them).
- The ease of the game was average because students specified that the game was not complex, however it involved a challenge in order to have best sustainable results.
- Regarding the preference, the study group preferred the use of simulators as a learning tool compared to the use of readings and was equally interested in using BS strategies in more class hours.
- Finally, in the aspect of learning, they noticed that it was useful for them since they understood better the concepts related to sustainable logistics, they had to use a multidisciplinary approach to get better results and support from their instructors was adequate to understand and take out the activity smoothly.
- A unanimous opinion on all respondents considered important the use of simulators as training tools.

Since there are no records, for the use of these tools, we consider this work as a preliminary study that will lead to a second step, in which more accurately measurements regarding decisions using the SNTDL would be possible, which is the ultimate goal of these instruments. So it is expected that new developments for new business games in other areas may be extended.

**References**


