008-0160

CREATING AND IMPLEMENTING A MODEL TO SIMULATE LOGISTICS OPERATIONS

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POMS 19th Annual Conference

La Jolla, California, U.S.A.

May 9 to May 12, 2008

Abstract

This work proposes a business game model to simulate the main logistics operations in a supply chain. The need of a simple tool, but, well structured, able to create a dynamic environment of learning, without making it too complex, motivated this study and development. The work begins with a comparative analysis between the main reference models about enterprise logistic, included in the bibliography related to best practices in logistics decision-making. Then, concepts of simulation and games are described, its interrelations, characteristics and importance as learning method. The definition of the best practices is, then, used to guide the construction of the main characteristics of the proposed model. The results obtained show the efficacy of the model as a tool capable of creating a dynamic environment for learning purposes to complement the traditional teaching techniques.

Keywords: Enterprise games, Logistics, Simulation, Learning.

1 INTRODUCTION

As new technologies appear and new scientific areas develop, new teaching-learning methods are being developed in order to follow the progress and the new realities imposed by the society. One of the main indicators of this progress is the widespread use of computers and the easiness to access internet-transmitted data, as a result. As computers become more and more present in people's daily lives, there is a need to develop a great variety of software to achieve a range of purposes. Among them, such as educational purposes, used as a supporting tool in the teaching-learning process. The development of educational software has recently been intensified under the modality of computer games. However, in the 60s, several American universities started the allocation of resources in order to research such teaching technology, generating a large scientific production on that topic.

In Brazil, this type of research began in the 70s, with the increasing use of recreational/educational games, at that time used as a support for the teaching in grade schools, such as games created to stimulate the learning of arithmetic or stimulate the children’s motor abilities. Regarding higher education, some universities are already developing and applying business games as a support for teaching some disciplines, mainly in the graduation area. As a successful example, the COPPEAD/UFRJ Logistics Study Center is mentioned, with the LOG and LOG *Advanced* games. However, such efforts for creating games modeled according to our characteristics and peculiarities are still incipient [1][2].

Regarding the private sector – especially in the training centers – the applications are still rare and it can be verified that, in most of the cases, such games are developed in other countries. Games that depict different cultures and legislations.

1.1 Motivation and Objectives

The advent of these issues provided the opportunity to develop a dynamic and interactive environment, adequate to aid the traditional methods in the teaching-learning process, either by motivating the students regarding research, by seeking for a greater understanding and assimilation

of concepts – as for the academic community – or helping in the training and empowerment for the managerial decision-making process – as for the business community.

The determination in contributing towards the accomplishment of this objective gave rise to the present paper, whose aim is to model and develop a computer game which simulate some of the main aspects which guide supply chain management. A game which can be played (remotely or not) by individuals or groups, who, aided by a mediator (the game administrator), will have to make some decisions which will be dynamically processed and analyzed. The intention is provide – for academic purposes – a tool serving either as a teaching instrument or an effective method which allows for the learning of concepts inherent in business logistics.

The choice for the logistics, as a topic, is due to the fact that it offers a wide variety of stimulating tasks which make its integrated management a major challenge. Another reason is the undermost amount of business games destined to the business logistics' teaching and training all over the country. It is an increasing – but timid – amount, when compared with the major demand coming from the utilization potential of this type of simulation applied to this study field. More important, the game provides the possibility of adjust variables and parameters of the model to reflect the conditions of the local reality of countries or regions considered. This paper presents the development of a business game called LOG IN, describing in the next sections conceptual and methodological aspects, some characteristics of the scenario and interface of the business game, and some final considerations.

2 METHODOLOGY

The methodology of development for this paper was based on three major stages: the first one was a comparative analysis among the main reference models in business logistics in the literature available. This was accomplished by means of a bibliographical research concerning the best practices for the procedures and techniques for the logistic decision-making process, in order to

attempt an approach to the "state-of-the-art" on the mentioned topic. This information was the conceptual base and guided the scope of the game to be developed.

In a second stage, a survey and an analysis were performed on business games focusing on logistics currently available in some of the major universities and research centers, in Brazil and abroad. The aim was to verify, in each game, how comprehensive such decisions were, as well as their strong aspects and limitations, interaction profiles with the user, type of technology applied, etc. From the definition of the theoretical and conceptual scope which guided the game structure, the study has focused on the definition and the experimentation of the variables and the parameters which would dictate the conditions for the business environment to be faced by the participants. The next step was the elaboration of the game, that is, the computational implementation itself, followed by the evaluation tests.

3 THE BUSINESS GAME – THEORETICAL ASPECTS

Currently, there is no consensus in the literature on the several types of teaching methodologies and practices available. Yet, there is no consensus, from such methods, on the existence of a grouping by classes [3]. Silva and Menezes [4], by adopting a direct and practical view of the several and viable teaching methods, classify them empirically in: Practical; Behavioral; Conceptual; Simulated. Among the cited methods, one can classify the business games – in the teaching-learning process – as a simulated method (a simulation), in which the training is inserted in a specific environment. This environment must be the as similar as possible to the real one.

3.1 Business Games

The business game is a type of simulation in which a sequential decision-making exercise is performed, thus looking at the systematic training of a team or all the teams, and working on the model of a business operation in which the participants assume definite positions as if they were in a enterprise [5][3]. Its main current utilization takes place in the business training. However, one of the difficulties is to approach the model to the reality, as much as possible. It is an excellent

teaching tool, being based on mathematical models that simulate the economic, business and organizational behavior [6].

3.2 Business Games Applied to Logistics

Nowadays, a new reality is faced: the power is more concentrated in the hands of those who manage the knowledge rather than of those who simply use it, for the latter depends on the first [7][8]. This new conception has been consequently imposing a new reality on the business organizations, in which the information management (when properly utilized) becomes essential to maintain the competitiveness. Especially in logistics, the information represents a fundamental resource in the decision-making process. Fleury [8] confirms such affirmation when he describes the current importance of having precise and timely information in order to maintain the efficacy of logistic systems. In this context, it is imperative to develop more and better systems, which can manipulate and properly deal with the information in the organizations, thus allowing for a greater efficiency in the decision-making process, by means of technology support. The games, as supporting tools to the logistic decisions, therefore tend to become more and more important and vital to the organizations, as they provide stimulating opportunities to the teaching, training and the simulation of decisions, both managerial and operational ones [9][10]. By means of games, the participants can experiment and test simulated reality conditions by analyzing afterwards the consequences to their decisions. This leads to the possibility for – virtually – making mistakes and receding in a competitive market that is increasingly and severely punitive towards such mistakes [2].

4 THE BUSINESS LOGISTICS – THEORETICAL ASPECTS

The logistics' activities (supply chain management) of an enterprise vary according to the type of organization structure belonging to each specific enterprise, or to the different opinions about logistics itself and the importance of the individual activities for the business operations. A typical supply chain to an individual enterprise is arranged on "corridors" or distribution channels, through

where input flows, products and information run. In general, the logistic activities rest on such distribution channels [2][11].

4.1 The Logistic Planning

The need to plan something comes from a natural inertia, which is intrinsic to the decision-making process. Such inertia means the time that necessarily has to elapse since the decision-making process itself until the appearance of its effect. Different decisions require different times regarding the effect given by its different inertias. The logistic planning is intended to deal with two major issues regarding the management of the supply chain: *the objectives of the service to the client* and *the global logistic costs* [11][12][13].

The ability to understand and manage such processes will define the ability the companies will have in minimizing its total cost for a specific service level [14]. The application of the concept of "total logistics costs" originates from this systemic approach. This application is the key for the logistics management [15]. The minimization of the cost for isolated activities may lead to the increment of the cost for other system components, increasing the total cost. This is a trade-off in terms of cost-benefit [16].

5 THE PROPOSED LOGISTIC GAME

5.1 The Conceptual Model

This paper proposes a supply chain model in which its basic characteristic elements are present: supply, warehousing, manufacturing and distribution [17]. Its operation dynamics takes place by means of the merchandise circulation (supply goods and finished goods) throughout successive time periods. By using a structured scenario, there has been an attempt to create a learning instrument which was able to comprehend the fundamental principles of all the chain without becoming it into a complex tool.

The game to be presented will depict the complexity of the logistic problems according to the activities' dynamics present in the chain. Also, it is intended to show how these problems can be

mitigated or aggravated according to the tactics used in the logistic planning to be implemented by each participant or team when attempting to deal with the customer service level and the global logistic costs. The game approaches, as guiding element for the logistic planning, the transportation and stock strategies, which in turn spread out into the simulation of the main decisions concerning the movement and stocking activities present in the logistics.

Market Geographical Characteristics

The game named LOG *IN* is based on a scenario aiming at replicating the performance of six enterprises belonging to a same industrial sector, located in the same competitive environment. This industrial sector comprises the manufacturing of a single type of manufactured product, named in the game PIN. This durable consumer goods is composed by three types of elementary raw materials, which can be transported by three types of modals: road, railroad, ship. In this game, the main objective is to make the teams develop the ability to offer the best service at the lowest cost possible. This cost-benefit relation is parameterized by means of some indices as a market share for the measurement of the service level and the total profit, for the measurement of logistic costs. The members to each team are in charge of the management of the enterprise's logistic system. In this sense, decisions regarding the purchase of raw materials, stock administration, production and distribution scheduling must be made. The decisions must be planned in an integrated and coherent way, with the participation of all the team, because decisions optimizing a specific function may affect others negatively.

Demand Characteristics

In order to assure the best profit and the best market share possible, it is necessary for each enterprise to plan a strategy comprising two basic goals: to stimulate the PIN's demand and to assure the product offer at the right time and quantity. The PIN price is fixed for all enterprises and for all markets. This way, a more intense competitiveness will be necessarily obtained through a reduction in logistic costs. An important characteristic related to the PIN's consumption is that advertising investments directly affect the market share of each enterprise, which causes an increase

in the demand in markets where it is advertised, making it responsible for assuring the product offer in the achieved markets. In quantitative terms, the sum of all the consumer markets represents a PIN's mean weekly demand of about 16,000 units. Out of this total, 28% are demanded by the central market and 12% for each local market. In addition, there are alterations in the consumption that promote a standard variation between +15% and -15% related to the mean demand. Also, there is the incidence of another random and unpredictable variation on that demand.

Production System Characteristics

The enterprises start the game with a zero initial stock of finished goods. In order to meet the diverse PIN's demands, it is necessary to properly plan the amounts of the product to be manufactured on a weekly basis. For this purpose, all of them have industrial systems that follow a set of specific characteristics, among them the basic transformation cost. It comprehends the facilities maintenance, the payment of employees, the purchase of equipment, etc., resulting in a weekly fixed expense. This estimation is based on the ideal amount of production, which is the optimal factory capacity, and refers to the production level in which the existing resources are better used. These values are arbitrated by the game administrator when configuring the initial scenario.

An addition cost due to the variation in the production volume may incur on the basic transformation cost. This cost is incident when the manufactured amount is higher or lower than the ideal expected for the production. Therefore, it comprises supplementary expenses related to rentals of new equipment, overtime payments, etc. (derived from the overload in the industrial system) or related to the opportunity costs due to the loss of potential sales (because of the sub-utilization of the factory). These numbers follow a mathematical relation which is graphically represented by the parabola, and they show how such additional cost behaves by increasing in terms of the volume of PIN's manufactured above or below the optimal arbitrated amount. The additional cost due to the production variation must be avoided, for it makes the production costs more expensive, thus causing the reduction in the enterprises' profit margin.

5.2 The Game Systematics

The LOG *IN* systematics is composed by a series of ordered step-by-step tasks, in which the players/teams interact with the administrator, receiving and sending files with information, reports and decisions, thus establishing a cycle that is repeated at each round. Figure 1 summarizes this cycle by depicting the composing tasks. The interaction among the teams can also be allowed, provided the rules are agreed before the beginning of the game, at the administrator's own discretion.

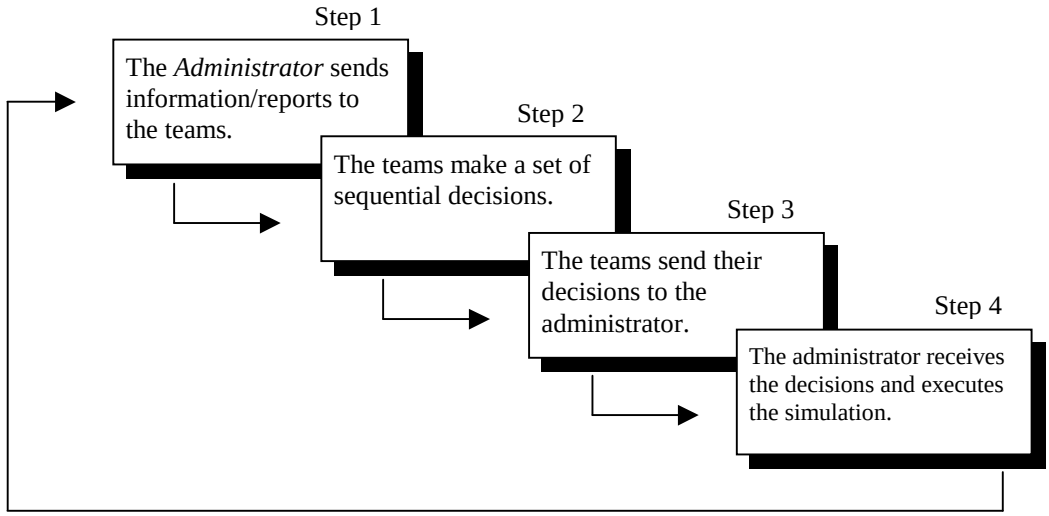

Figure 1 - The LOGIN Game Systematics.

Firstly, it is presented a scenario previously configured by the administrator, in which all the needed information is made available, so that the teams can start the first round. With these data, each team is ready to start the round, which in turn is converted into a set of pre-determined and sequential decisions. After the decisions are made, they are sent by the teams to the game administrator, so that the round simulation can be executed. The simulation results are converted into reports, which are sent to each team along with new necessary information (update) on the game scenario, so that a new round can be started. This entire cycle constitutes of a round or period, and it is repeated over and over, up to the moment that the administration declares that game is over, and it can be either arbitrarily performed or previously arranged with the teams.

Decision-making Process Summary by Period

The main task in the LOG *IN* dynamics is the decision-making process that each team executes after the data are received and analyzed, and the information is sent by the administrator (figure 1, step 2). Each decision deals with very important concepts which are interactive and are part of the daily routine regarding supply chain management of most enterprises belonging to several productive systems. In the game, these decisions are interconnected and sequentially arranged so that it can replicate as much as possible the enterprises' performance strategy logics. Figure 2 briefly describes this sequence.

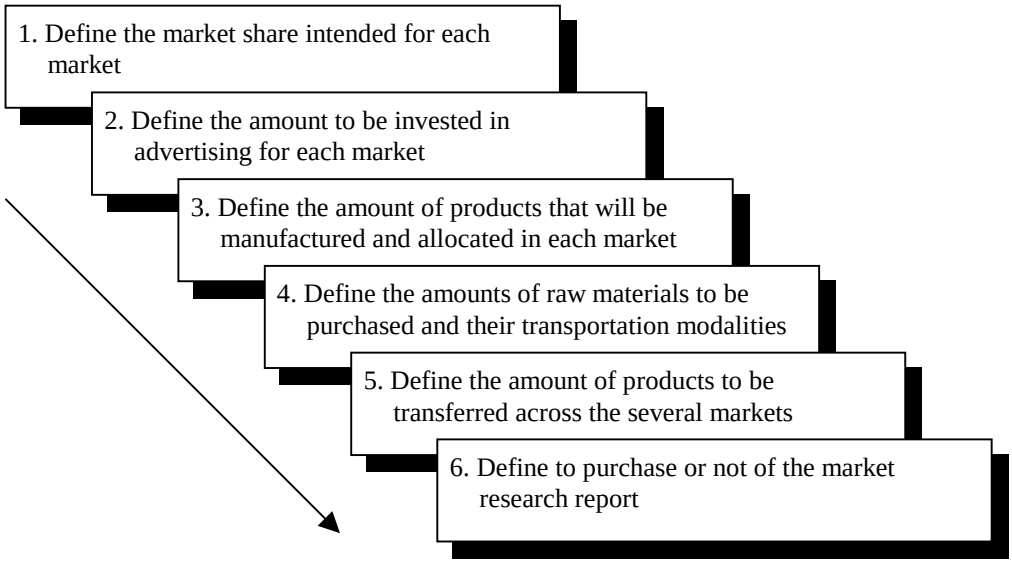

Figure 2 - The decision-making process sequence executed by the teams.

5.3 Description of the Software Interface

It is presented below the main LOG *IN* interfaces. The game starts with a choice that offers the user (by entering a specific password) two possibilities: login as a player or administrator. Each option offers access to two main game screens, respectively: the player’s control screen and the administrator’s control screen. Together, they allow for the execution of all the functions in the game, in addition to presenting graphs and relevant information regarding the rapid access for the monitoring of the performance of the team and the rounds themselves.

Administrator Interface

The administrator's control screen presents, in its upper part, a main menu composed by five items. The item "Game" allows the user for creating and saving new rounds or simply open and close games files which already exist. In the item "Scenario", it is possible to view, edit and print the current scenario of the game. It is also possible to check a history for occasional modifications performed across the rounds.

In the item "Decisions", the administrator imports to the system the decisions sent by the teams and process the simulation. Conversely, the information needed to start the next round is exported. In this game, all the file exchanges between the administrator and the teams can be performed by means of discs or via net (Internet or Intranet). The item "Reports" views, prints and exports weekly reports and the market survey report to each team. The item "Help" allows for the access to the administrator's and player's manuals. Also, a text on logistics is made available to be utilized as a didactic material. In the remaining screen area, useful information on monitoring is made available. Below, four graphs with several performance summaries are presented: On the left side, one can notice the total demand history for PIN and the market share percentage of each team until that period. On the right side, one can find the accumulated profit and the general score for each team. Figure 3 exemplifies an administrator's control screen (in Portuguese langue) for a game in its tenth round.

Player Interface

The player's control screen presents an interface which is very similar to the administrator's control screen. Its main menu is composed by the same five items (Game, Scenario, Decisions, Report and Help), except for some specific sub functions which are necessary to serve the peculiarities of this type of user.

In the item "Decisions", the player imports to the system the information sent by the administrator to the beginning of the round and executes the decision-making process. The decisions made are once again exported so that the administrator can execute the simulation.

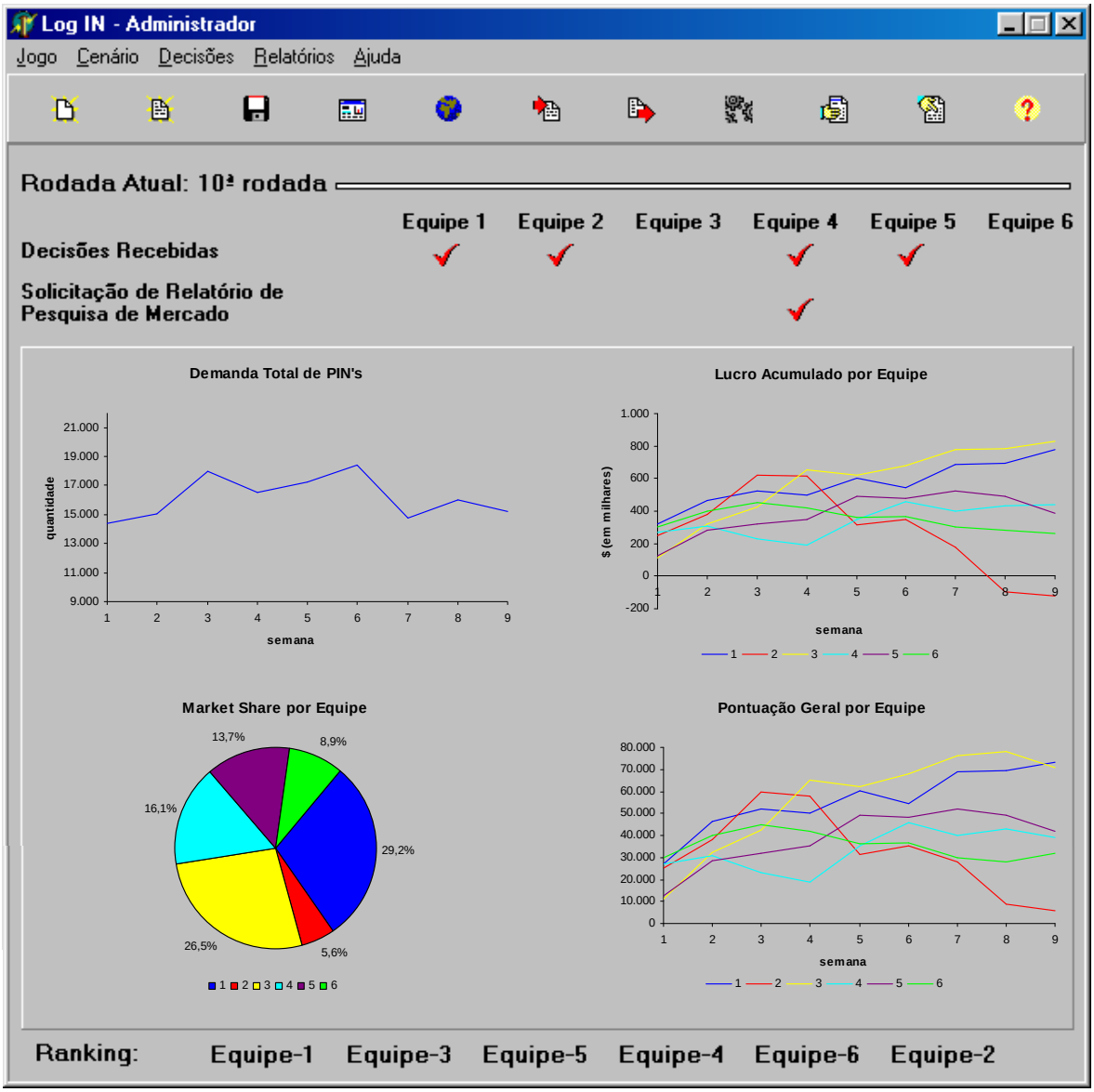

Figure 3 - Administrator's control screen.

The item "Game", for example, allows for the user to open and save game files which already exist, but not to create new games. In the item "Scenario", there is no option for editing the current game scenario, but only for viewing and printing it. However, it is also possible to check a history for occasional modifications performed across the rounds. The item "Reports" imports, views and prints the market survey report. These two last resources are also applicable to the weekly report. The item "Help" just allows for the access to the player's manual, in addition to the didactic text.

The useful pieces of information made available in the remaining screen area are: the current game round; the stages for the decisions made up to the moment and the team's general

performance data (market share, accumulated profit, score and ranking). The screen is completed by four graphs that allow the team for monitoring its performance in a constant and fast way.

6 FINAL CONSIDERATIONS

A business game – regardless of its specific objective and degree of sophistication – cannot fail to present some essential characteristics, such as: (1) to be able to start a game by putting the players in equal conditions to play; (2) to be able to define clearly the winner; (3) to present recreational components, making it attractive; and (4) to present variables with a certain degree of unpredictability. This game has an advantage over other games: it brings all these characteristics, while some in others models conceived last years is missed. Other important characteristic is the possibility of adaptation of scenarios through changes variables to reflect different realities. As example, costs of transportation by train in Brazil are more expensive than Europe or United States. Then countries have logistic modal with differences, which have to be set in a game.

Some applications of the game were made, so that the game's performance could be evaluated. The tests were carried out in a previously chosen reference group, composed by Petrobras's trainee production engineers, who were taking a Logistic long-term course at the enterprise's corporate university. The world-class structure made available by the enterprise and the group's willingness to contribute to the research (in addition to the excellent qualification of its members, of course) were decisive elements in the choice. After the tests, all participants were requested to fill in a closed questionnaire, aiming at obtaining feedback, as well as evaluating the teaching value of the game, according to the presence of some pre-determined elements and characteristics. This evaluation made use of ten parameters on business game analysis. An increasing scale from 0 (zero) to 5 (five) for quantification purposes was associated with each parameter. All questionnaires were fully filled in and delivered, totalizing eighteen sets of answers (six teams composed by three people by team). The total score was of 44.8 points, that is, 89.6% of the 50 possible points.

This type of research is not intended to carry a “statistical rigour”, able to measure precisely the efficacy level of the model as a teaching tool. However, the results were extremely positive, which gives the authors the privilege to affirm that this work has achieved its aim, as an instrument capable of effectively aid in the knowledge transmission process in all its dynamics. By playing the game, the participants had a concrete and fast opportunity to get to know all the main concepts related to the business logistics, in addition to understanding how its processes and activities interact within a supply chain. It was also verified that, in general, the contact with resources related to the information technology served as a motivator for the participants concerning the interest in learning logistics.

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