GAME-BASED LEARNING: TEACHING SYSTEMS THINKING IN AN ICT ENVIRONMENT

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Abstract. Several studies highlight that the recent economic crisis is a consequence of the lack of *systems thinking* prevailing in our current economy. Instead of analyzing the interdependencies among processes, decisions, and companies, managers tend to tackle issues relying on individualistic approaches. The main challenge for professors comes from the difficulty of teaching students the core concepts of *systems thinking* and, thus, the need for cooperation. In order to facilitate the understanding of the importance of holistic approaches versus reductionist ones, we propose the implementation of game-based learning techniques. More specifically, in this paper we focus on the Beer Distribution Game, the Freddie's Newsstand Exercise, and negotiation games. All of them represent systems where problems arise when there is a lack of *systems thinking*. After students notice the emergence of inefficiencies when they take an individualistic approach to decision-making, they are told to play the same game once again with a systemic methodology. In this way, they are able to realize that holism clearly outperforms reductionism. Contrary to traditional practices where face-to-face prevails, these games have been developed in ICT environments, where instructors can provide immediate feedback to students in order to enrich discussions. Our experience shows that the experimental nature of these games has proven to be very effective in helping students understand the causal relationships between decision-making and the returns obtained.

Keywords: Game-based learning, ICT, role-playing, *systems thinking*, holistic management.

INTRODUCTION AND OBJECTIVES

The recent economic crisis can be understood as a consequence of the fact that globalization has not yet been able to develop systemic dynamic properties within its economic networks to deal with growingly complex environments (Schweitzer et al., 2009). Since economies are increasingly built on interdependences, businesses' concerns to adopt new managerial approaches based on holistic[1] perspectives has surged. In this sense, both practitioners and academics emphasize the critical need for understanding the structure and dynamics of economies as a whole. Nevertheless, the systemic approach has spread in a very irregular way since its origins (Costas et al., 2015). In other words, the reductionist[2] approach is still widespread in practice, which significantly hinders the overall efficiency (Sterman, 1989).

In the current globalized economic scene, Management professors are faced with the challenge to instil the holistic thought in their students. As a result, they have to create a new learning environment where students care about the interdependences among processes, decisions, and companies. In other words, they have to teach *systems thinking* (Sterman, 2000). In contraposition to the "divide and conquer" paradigm for problem solving, *systems thinking* looks at issues on their entirety. "It is a discipline for seeing wholes, namely a framework for seeing interrelationships rather than things and patters rather than snapshots" (Senge, 2006).

Our article shows how scholars can teach *systems thinking* through a game-based learning approach in an ICT (Information and Communications Technology) environment. We aim to: (1) prompt students to discover the significant inefficiencies induced by the reductionist approach; (2) provide them with strategies and methodologies which allow them to implement holistic solutions; and (3) show them how these systemic approaches outperform traditional methods.

Holweg and Bicheno (2002) emphasize the relevance of simulation to enable the development and deployment of holistic solutions in Management ("simulation helps companies to understand that their optimal state can only be found by considering the effects of their own decisions and collaborating within the supply chain"). For this reason, we suggest that role-playing simulation exercises fit perfectly with our goal. More specifically, we have used the widely used Beer Game, Freddie's Newsstand (from the well-known newsvendor problem), and classical negotiation games. In addition, we have taken advantage of the possibilities offered by an ICT environment in terms of agility and immediate feedback (Kiili, 2005). In the following sections we describe in more detail our game-based learning approach and how we have implemented in our courses.

[1] Holism underscores the idea that systems and their properties should be viewed as a whole and not as a collection of parts.

[2] According to the reductionist approach the overall strategy of a system is obtained as a sum of individual strategies, thus ignoring the relationships among them.

DEVELOPING THE IDEA

In order to introduce our students into the philosophical contrast of *holism versus reductionism* in terms of problem solving, we start by discussing counterintuitive questions using real-world similes[3] to present core concepts, such as:

- ✓ Do relationships matter when studying the performance of a distribution system or is it enough to study the various parts that conform it? This question can be addressed through the "chain simile". By using this simile, students can assess that certain properties of a chain can be analyzed by looking at each of its parts while others cannot. For example, a person can weigh a chain by adding the weight of each one of its parts. However, to study its resistance the links must be also taken into account since they play a key role. The same can be applied to supply chains. In this sense, while it is possible to analyze its costs by adding the costs of its echelons, this approach is not useful for assessing its ability to quickly adapt to the rapid changes happening in its business environment. Therefore, even though reductionism offers an interesting solution in some cases it can lead to significant errors in others.
- ✓ Does every improvement in a production system lead to an increase in the overall performance? To tackle this second question we use the "scouts simile". If we imagine a boy scouts troop going through a forest, its walking speed is defined by the slowest of its scouts. Hence, assuming that our goal is to make the troop go faster, we would be wasting our resources if we targeted the wrong scout. Similarly, companies usually allocate resources in areas where they do not lead to an overall increase in performance (i.e., far from the bottleneck).

After this discussion, students are introduced to managerial decision-making through role-playing simulation games. In this paper, we focus on three of them: the Beer Distribution Game, the Freddie's Newsstand Exercise, and negotiation games. Each one has been carried out during a specific managerial workshop, as the overall process requires between three and four hours. In all cases, the development of the game encompasses four steps. First, students are encouraged to play them from an individual perspective. Second, we observe the inefficiencies which have been generated and we discuss how the games can be played from a holistic point of view. Third, they play the same game once again, this time collaborating among themselves. Finally, we examine the differences in the key performance indicators of the game and we debate about the lessons learned.

The Beer Distribution Game

The Beer Distribution Game is a simulation exercise developed at the MIT Sloan School of Management which aims to teach the main principles of distribution

[3] Both similes subsequently explained come from Goldratt (1990).

systems (Goodwin and Franklin, 1994). Its scenario is defined by a single-product linear supply chain, formed by four main nodes: factory, distributor, wholesaler, and retailer. Students are divided into small groups to play the role of each one of these echelons. At the beginning of each turn (a simulated week), they receive the product from the upper level and an order from the lower one. Then, they satisfy this order from inventory –if it is not possible to fulfill it, they create a backorder (which will be satisfied as soon as net stock become available). Finally, they order an amount of beer to their supplier, which is the only decision they have to make during each period. The goal of the supply chain nodes lies on minimizing cost, which are incurred in two different ways: carrying inventory and breaking stock (back-ordering).

The students' individual behavior usually obeys an order-up-to[4] replenishment policy (Sterman, 1989) while playing the game. Although the game considers only two sources of inefficiencies in this type of supply chain (uncertainty regarding customer demand and lead time), greater problems are generated along the supply chain due to the use of this kind of policy, such as the strategic Bullwhip Effect[5] (Wang and Disney, 2015). For this reason, the performance of the participants in the Beer Game is far from optimal. It is usual for students to start thinking in this phase that "the enemy is out there" (Senge, 2006), thus assuming that they have made the right choices and the bad overall performance is their colleagues' fault. It is important that the teacher helps them eliminate this mindset, as the interaction of individual decisions is the one which produces harmful dynamics in the supply chain in contrast to the ones achieved through collaboration (Sterman, 2000).

Therefore, to play the Beer Distribution Game appropriately we need to plan a systemic play style. To do so, we resort to the most well-known holistic paradigm for production and distribution systems: Lean manufacturing (Womack and Jones, 1996). Kanban Control is Lean's simplest solution to manage the flow[6]. This system is based on restocking only what has been consumed. In other words, in the Beer Game scenario, the order is issued to replace the gaps generated by satisfying orders. After explaining the main concepts of Lean manufacturing, students replay the Beer Game using its precepts.

Freddie's Newsstand Exercise

The newsvendor problem has been widely used in Operations Management to determine optimal order rates in case of uncertain demands for perishable products (Petruzzi and Dada, 1999). It focuses on a single echelon (the retailer), which makes a pre-defined earning for each sold product and a pre-defined loss for each unsold product. Freddie's Newsstand (Hillier and Lieberman, 2009) spreads out the previous problem to a double-echelon model (i.e., factory and retailer). By including the factory

[4] They order to recover a gap between the actual and the desired (safety stock) inventory.
[5] This concept refers to the amplification of the variability of orders as one moves up the supply chain.
[6] In specialized courses, we also apply more complex methods, such as CONWIP.

in the scenario, a decision variable is added: the refund offered by the factory to the retailer per unsold newspaper. In this case, different groups of students play either the factory or the retailer. Obviously, both kinds of groups aim to maximize their profit. To do so, the retailer's decision is limited to the quantity it has to order and the factory only decides the refund to give per unsold newspaper.

In a first approach, we play without refund. Thus, the participants who act as the factory intervene as mere observers and its profit is solely determined by the ordering decisions of the retailer. We write down the net profit obtained by each echelon during the game. Next we discuss the results of both groups. The students acting as the factory tend to be more disappointed since they especially care about the lost sales due to an insufficient order from the retailer. On the contrary, the retailer assumes that lost sales are a better solution than ordering a larger number of newspapers which will be eventually not sold.

From that point on both groups understand the need for a refund. Namely, the need for a systemic approach to the problem. More specifically, this is called incentive alignment (Simatupang and Sridharan, 2005) and promotes collaboration through the share of costs, risks, and benefits within the economic system. The refund encourages the retailer to order a greater number of products because the risk of unsold newspapers is largely reduced.

Negotiation Games

Negotiation is a process in which several groups with common and contradictory goals express and examine specific proposals to reach a potential agreement. Negotiation is one of the key directive tasks since managers routinely face challenging situations that require negotiation, such as building coalitions, dealing with power imbalances, leading teams, and representing their company (Watkins, 2002).

Traditionally, negotiation has been based on the so-called competitive or distributive approach, where both parties understand that there is a resource pie to be divided and, thus, they adopt a posture of rivalry (Spangler, 2003). This eventually leads to a zero-sum game where one side's loss is the other side's gain. In order to test this negotiation approach, the class is divided in groups of two. In each group there is a buyer and a seller, each one subjected to specific circumstances detailed in an information package given by the professor. Subsequently, students apply their negotiation skills with the aim of achieving a greater part of the pie.

After playing this round of the game, we present them with the cooperative (or integrative) approach to collaboration, where both parties understand that the resource pie can be increased by looking for creative solutions to the conflict (Spangler, 2003). We discuss about the creative solutions that could have been found in the previous negotiation exercise, as well as the obstacles that hinder the achievement of a collaborative solution (e.g., the difference in each party's bargaining power). Lastly, we perform a cooperative negotiation exercise using the same groups previously defined. However, instead of playing buyer and seller, this time both

students assume the role of producers located in different parts of the world. In this scenario the different goods have different values for each producer and, by negotiating, they should be able to achieve a solution where both of them increase the value of their monetary assets.

The Role of the ICT

Although the games outlined in this section have traditionally been played in face-to-face workshops, we have developed them in an ICT environment because it grants students a more agile learning experience (Kiili, 2005). On the one hand, participants observe the progression of the game and the results in real-time, which provides them with an interesting feedback to cope with the problems identified. In addition, once the game is finished, the instructor is able to access the statistics windows to present the main key indicators in each case for a further discussion with the students. On the other hand, errors along the process, which significantly slow down carrying out these games under a physical support, are greatly reduced.

The software that we have worked with has been chosen to support interactive classroom situations. More specifically, regarding the Beer Game we have used a free facilitation program available through The Beergame Portal (Riemer, 2012). This outstanding software is a server application started by the instructor and configured by means of a web browser[7]. In the case of Feddie's Newsstand Exercise and the negotiation games, we have used an Excel spreadsheet through a collaborative edition framework provided by Google Drive. This graphically shows the evolution of the net profit obtained by the various groups within the class, which allows them to adjust their rent-seeking decisions.

DISCUSSION OF THE OUTCOMES AND CONCLUSIONS

The underlying idea across the three games described in this paper is that any non-coordinated system will experience complications arising from a lack of *systems thinking*. These problems represent real-world inefficiencies that obstruct the economic system and reduce companies' competitiveness. In this vein, although managers recognize that their organizations are complex networks of interrelated systems, several studies indicate that their behavior usually give little weight to this notion. Even though this might seem contradictory, it is clear that managers have experienced some issues when applying the concepts of *systems thinking* to the strategies of their firms.

But… why does this happen? The main reason is that generally speaking people has not been educated to apply these systemic ideas. On the contrary, they have been trained to solve problems through individualistic approaches. This can be clearly observed when students play the Beer Distribution Game. When they try to

[7] Once the instructor starts a new game, students can simply log on to the server from their computers. To do so, the instructor simply hands out a URL to the students.

optimize their results, they tend to create information distortions in the system (errors in forecasting, shortage gaming…). This significantly damages other echelons which, in turn, deteriorates the students' performance. After noticing the inefficiencies, students try to react but they do not achieve it due to their reductionist approach.

If they were to use a holistic perspective like Kanban Control their results would be dramatically improved. Unlike traditional ways of playing the Beer Distribution Game based on forecasting, the replenishment orders with Kanban Control obey to the actual demand of customer. Since they are aimed at maintaining inventory levels, the work-in-progress is constrained and, thus, the Bullwhip Effect is reduced. In other words, when students apply Lean's rules to the Beer Distribution Game supply chain, they achieve a higher customer service level and, at the same time, they reduce holding costs. Therefore, they can easily witness the advantages induced by the systemic approach.

Regarding Freddy's Newsstand, this exercise helps students understand the need for cooperation. The students who act as the factory are initially averse to offer a refund to the retailer per unsold newspaper since, as they first argue, "it is not their problem that the retailer has to assume the lost sales". Nevertheless, they soon realize that in fact it is because offering the refund can increase the risk assumed by the newsstand, hence decreasing the number of missing sales. Under these circumstances, they spend several periods looking for the optimal refund after finally assuming that incentive alignment is essential for improving their profit. Putting it differently, they realize that collaboration leads to a win-win situation.

Finally, as regards negotiation games, students first visualize how a competitive approach fosters the notion of implementing coercive tactics that forces a zero-sum solution. Consequently, they notice that cooperating in a negotiation is an effective way to increase the satisfaction of both participants. More specifically, they realize the importance of coopetition, that is, cooperative competition, in negotiations.

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