Matching Role Playing, Balanced Scorecards and System Dynamics modelling in management training: the "Strategic Micro-Factory"

Barnabè Federico, Busco Cristiano, Lambri Maurizio, Zatta Gianfranco[1]

Introduction

The article is based on the presentation and use of a business game called "Minifabbrica strategica" ("Strategic Micro-Factory"). The aims pursued by this paper are two fold. First the paper aims to show how business games, and more in detail role playing games, may be successfully used in management education, since they provide safe contexts in which is possible to support processes of knowledge elicitation and knowledge sharing, develop collaboration and team-working attitudes among participants, promote forms of individual and organizational learning and improve the ability to take decisions and design managerial policies in complex and dynamic business domains. Second, the paper addresses the problem of measuring and evaluating the performance and the improvements made by the participants to a gaming experience, adopting to this end two specific tools: a performance measurement system (the "Balanced Scorecard") and a System Dynamics model.

Keywords

Role playing; Balanced Scorecard; System Dynamics; Supply Chain; Management training.

1. Introduction

High dynamics and complexity have become common features in nowadays business domains. This implies strong interaction and coordination between the companies and managers involved in the decision-making process, as well as a very short response time and the ability to use strategic thinking skills. More in general, this also implies to understand the behavior shown by the systems we manage and to be able to quickly take decisions and design feasible managerial policies within such contexts.

Within modern business domains, such requirements have resulted in the development and adoption of innovative policies for staff recruitment and training, specifically aimed at ensuring that human resources are well equipped, own team-working skills and adopt a problem-solving attitude in their jobs. More in detail, in the field of management training and education, the above mentioned factors have led researchers and companies towards two specific directions:

a) first, towards the development and the adoption of specific tools to support and facilitate processes of deep understanding, analysis and learning;
b) second, towards the development of innovative performance measurement and strategic management systems able to assist companies in defining business strategies in complex and dynamic business domains and to monitor and evaluate the results of the actions carried out.

[1] Federico Barnabè, Department of Social and Business Studies, University of Siena, Italy (barnabe@unisi.it); Cristiano Busco, Department of Social and Business Studies, University of Siena, Italy (busco@unisi.it); Maurizio Lambri, GMV Consulting, Milano, Italy (m.lambri@gmvconsulting.it); Gianfranco Zatta, GMV Consulting, Milano, Italy (g.zatta@gmvconsulting.it).

In reference to these two directions, the paper aims to present and discuss a comprehensive approach to management education based on the use of:

- a role-playing game, representing the functioning of a typical manufacturing supply chain;
- a performance measurement system (kwon as Balanced Scorecard);
- a System Dynamics simulation model.

The paper is subsequently structured as follows: the next section focuses on the types of tools that can be used to support learning in management education, giving primary relevance to experiential learning and role-playing games; the third and fourth sections briefly discuss the main advantage of using the Balanced Scorecard as the underlying methodology for measuring and evaluating performance (even in simulated environments) and highlight the importance of System Dynamics in providing the methodological principles and the operational tools needed both to analyse and understand complex systems and make sense of gaming experiences. The fifth section focuses on a specific business game, called "Minifabbrica Strategica" (i.e. "Strategic Micro-Factory"). Some final remarks will be presented afterwards.

2. Using role playing in management education

Over the past years many authors have contributed to the debate on which educational methods and learning styles have to be preferred when dealing with management education/training and particularly when learners are called to face complex and dynamic business domains (e.g. Sterman 1992; Wirth 1992; Graham *et al.* 1992; Lengnick-Hall and Sanders,1997; Berggren and Söderlund 2008).

In its basics, education entails to transfer specific skills to students and increase their level of knowledge. However, different educational methods not only are based on the use of different tools (e.g. a traditional lecture vs. a case study), but are also usually aimed at stimulating and supporting differentiated typologies of learning.

Among the possible approaches (which include auditory learning, visual learning, problem based learning, situated learning and inquiry learning), specific relevance has been given to *experiential learning*, which is based on being engaged in hand-on work activities, where direct experience plays a fundamental role (Gentry 1990).

More in detail, experiential learning may play a relevant role in management education taking into specific account the way in which learning very often occurs. To this end it is possible to refer to two key definitions centered on learning and the role played in the learning process by experience: Kim (1993: 38) defines learning as "the acquiring of knowledge or skill", while Kolb (1984) refers to "the process whereby knowledge is created through the transformation of experience".

Thus, two specific aspects are combined within the concept of *learning*: the acquisition of new knowledge or skills/abilities and the relevance assumed by experience/experimentation.

In this regard, it is also interesting to cite Senge's thought (1990: 23), where he argues that "the most powerful learning comes from direct experience. Indeed, we learn eating, crawling, walking, and communicating through direct trial and error - through taking an action and seeing the consequences of that action; then taking a new and different action. But what happens if the primary consequences of our actions are in the distant future or in a distant part of the larger system within which we operate? We each have a «learning horizon», a breadth of vision in time and space within which we assess our effectiveness. When our actions have consequences beyond our learning

horizon, it becomes impossible to learn from direct experience. Herein lies the core *learning dilemma* that confronts organizations: *we learn best from experience but we never directly experience the consequences of many of our most important decisions*".

It is our opinion that this situation opens up great opportunities for the use of *role playing* and *business game simulations* in management contexts.

Role playing games and business games are increasingly used in management training programs (Elgood 1997) to pursue specific educational aims, there included objectives of individual and organisational learning as well as improvements in strategic thinking skills and team working attitude (Sterman 2000).

The definition of a *business game* is substantially wide, including any kind of simulation and role-playing game capable of artificially reproducing specific business systems with their operating conditions and decision-making rules. As highlighted by Crookall, Oxford and Saunders (1987: 147), simulation and role playing can be seen as tools to represent "some real-worldly system, as a symbol with a referent, and thereby drawing its essential meaning from that referent. However, during performance participants do not necessarily see things in this way. For them simulation is a very real experience; it develops its own reality and becomes discontinuous during performance, with any other world or system".

Starting from these considerations, in this paper we will primarily refer to role playing games and business games as tools able to provide a safe environment in which players can interact with a simulated business domain, firsthand experience the working and managerial conditions of such business context and directly observe the consequences of the policies and actions carried out.

More in detail, role playing games have the potential to be effectively used in management training since they rely on some fundamental learning conditions, as follows.

a) Learning from experience is considered very relevant for human development (Lewin 1951) as learning occurs more easily when players are mentally active during the learning process; in such a way, participants would live a "concrete" experience (Kolb 1984), able to transform the new knowledge acquired through experience into practical skills and competences (Lewis and Maylor 2007).
b) Double loop learning (Argyris 1993) is more likely to occur through experimentation in a virtual or simulated world (Sterman 2000) since it is possible to challenge and influence participants' mental models (Senge 1990) in a safe and free-risk environment.
c) Transfer-appropriate learning can be achieved by helping participants to acquire new information and skills in contexts as close as possible to those in which they will eventually need to use them (Tomlinson and Masuhara 2000: 159); therefore any role playing game should be realistic and should represent the operational context under investigation as close as possible to reality.
d) Role playing games have the potential to provide the conditions for developing forms of "co-production" of knowledge, thus contributing to overcome the traditional barriers to academic-practitioner learning (Smeds 1997).
e) Interacting with virtual worlds, players usually use their tacit knowledge (Polanyi 1967) and improve their skills and abilities; in this way, new knowledge can be obtained more quickly and for conditions not observable in real life (Vennix 1996).

In sum, it is our opinion that simulation and gaming may assist managers and students in conceptualizing new information, sharing a common language, providing a structured way of thinking about complex problems.

However, role playing games (and, more in general, business games and simulations) may also have some limitations. For instance:

- it is not always clear *why* and *when* knowledge sharing occurs (or may occur) in simulated environments (Chua 2003: 117);
- players may adopt a "trial and error" strategy in their playing experiences, not giving enough relevance to the gaming session, or may even suffer form the so-called "game-syndrome" (Senge and Sterman 2000: 211-212; Sterman 2000: 36);
- the effectiveness of a gaming experience may be hampered from what the players import from their "real world" (Crookall *et al.* 1987: 170), there included their "mental models" (Senge 1990) and "defensive routines" (Nelson and Winter 1982);
- the gaming experience may be not fully effective since the players may lack management tools and competences needed to make sense of their simulation experience (McKone *et al.* 2003) and properly evaluate the outcomes of their decisions.

In reference to the previous considerations, it could be useful to combine the use of role playing with two additional "tools", in order to rely on:

a) a sound performance measurement system able to monitor players' performance and provide a complete report of the outcomes of the gaming sessions;
b) specific qualitative (e.g. maps and diagrams) and quantitative (i.e. a mathematical simulation model) tools needed in order to represent the underlying cause-effect structure of the simulated business domain and perform policy analysis.

In order to address the first problem and part of the second (the mapping phase), the attention will be subsequently focused on the strategic management system known as *Balanced Scorecard*, whilst subsequently the attention is placed on the use of the methodological principles and the tools provided by the *System Dynamics* methodology.

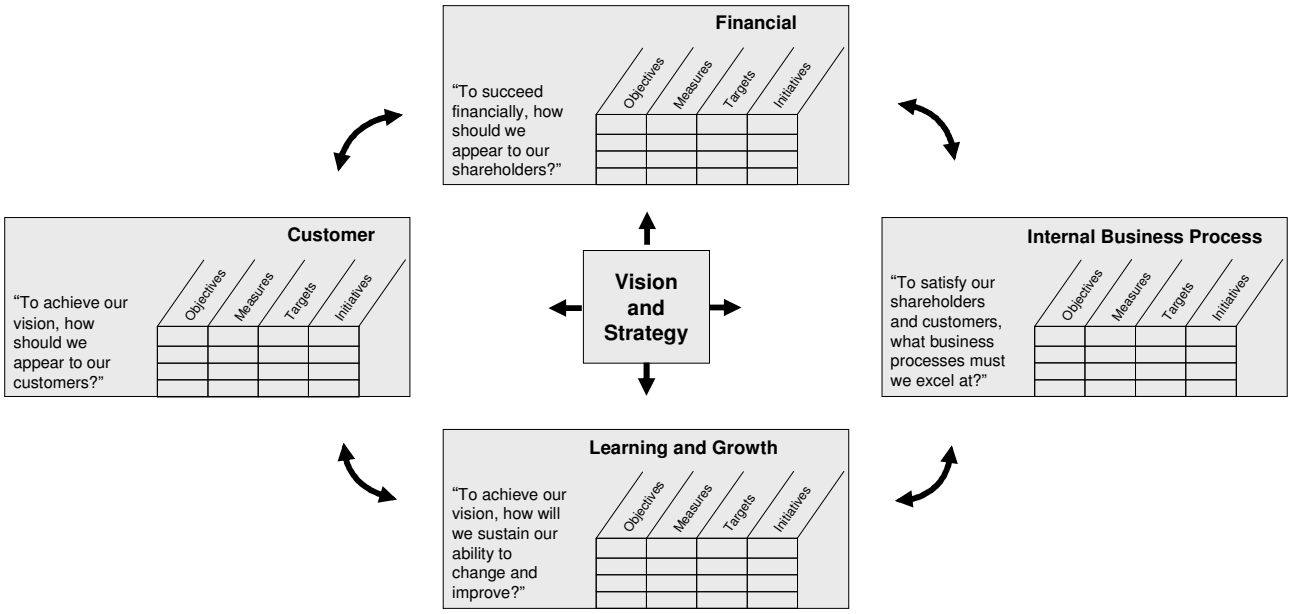
3. Using the Balanced Scorecard as the main underlying measurement system for gaming experiences

The Balanced Scorecard is a performance measurement system theorized by Kaplan and Norton at the beginning of the 1990s (Kaplan and Norton 1992).

This system provides a holistic approach to performance measurement, being able to link an organization's performance metrics in four main perspectives: as its authors describe it (Kaplan and Norton 1996), "the Balanced Scorecard is a concept for motivating and measuring business unit performance. The Scorecard, with four perspectives – financial, customer, internal business processes, and learning and growth – provides a balanced picture of current operating performance as well as the drivers of future performance".

The following figure represents an example of a BSC architecture.

Figure 1 - *Simplified representation of a BSC template.*



Source: Kaplan and Norton (1996: 9).

Each perspective is based on lagging and leading indicators and contains the prevision of actions to be taken in order to reach the pre-set targets. The lag indicators are outcome measurements and indicate the results of a strategy; the lead indicators are driver measures, able to illustrate incremental changes that ultimately will affects the outcomes. Financial measures usually tend to be lagged. Therefore, the measures that have been selected for the other perspectives need to contain some leading indicators.

Overall, the four perspectives can be represented as an interlinked hierarchy and "objectives should be linked in cause-and-effect relationships" (Kaplan and Norton 2004: xii). The firm's strategy underlies the whole scorecard, as the measures for each of the four perspectives are drawn from this strategy.

This is particularly relevant taking into consideration a specific mapping tool included within the overall BSC framework: the *Strategy Maps* (Kaplan and Norton 2000, 2001 and 2004). Basically, a strategy map is a diagram that describes how an organization creates value by connecting strategic objectives that are in explicit cause-and-effect relationships with each other into the four BSC perspectives. It also represents a qualitative way of providing a *macro* view of an organization's strategy, prior to constructing metrics for the evaluation of performance against strategic targets.

In sum, the BSC framework enables to simultaneously control several key performance areas, through specific key performance indicators linked by cause and effect relationships and to graphically represent such indicators and their causal linkages, thus contributing to a better formalization and understanding of the systemic structure of the specific business domain under analysis.

In recent years, the Balanced Scorecard has attracted considerable interest and many scholars suggested its use for different purposes. Furthermore, in the analysis of management and accounting literature, many authors supported the positive role and usefulness of this strategic management

tool[2], underlining its key strengths and advantages, in: being *simple*; being developed in an *interdisciplinary way*; conveying a *systemic view* of the organization; having the potential to *enhance management capabilities*, especially in terms of its capacity to increase management's understanding of the business and of the causal relationships between non-financial and financial measures.

It is authors' opinion that these advantages can have great value also in simulated environments: if used to measure players' performance and support understanding of cause-effect links, the BSC has the potential to be a great support for learners engaged in role-playing games.

Moreover, the potential of the BSC can be greatly increased when matched with qualitative and quantitative tools based on System Dynamics methodological principles, as shown by some authors (Akkermans and Van Oorschot 2005; Bianchi and Montemaggiore 2008; Capelo and Ferreira Dias 2009; Barnabè 2011).

4. A brief note on System Dynamics

System Dynamics (Forrester 1961) models and tools have proven their validity over more than 40 years of application in a variety of different fields. Based on the concept of feedback and on information-feedback control theory, System Dynamics can be considered as "a perspective and a set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System Dynamics is also a rigorous modelling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations" (Sterman 2000: vii).

As stated above, it is well known that System Dynamics provides a number of different tools, both *qualitative* (such as diagramming tools, "causal loop diagrams", "stock and flow maps", etc.) and *quantitative* ones (formal models based on a rigorous mathematical language) in order to identify, portray and analyse the critical feedbacks determining the dynamics of the systems under analysis. In particular, computer models, formally combining both maps and knowledge, as well as theory and practice, are key elements of the System Dynamics methodology.

If used in a management training programme (based on a role gaming experience and a BSC in order to monitor key performance indicators), System Dynamics allows to convey sense-making to the whole gaming experience: building the maps and the model, the modeller and the players filter and organise knowledge derived from the gaming experience, individual mental models and "real" data (the data provided by the BSC), while in a second stage, using the computer model, it is possible to learn about the dynamics of the specific business domain under analysis and to further develop players' understanding and strategic thinking skills.

More details and insights will be provided presenting and discussing the specific role playing game we refer to in this study.

[2] This is demonstrated by the large number of articles highlighting its strengths and advantages, a variety of books containing case studies of companies or public administrations that have adopted the BSC, articles focusing on the diffusion of the BSC in specific geographic areas, and a number of software houses that provide tools for BSCs, as well as reports and case studies presented on the web. For a literature review see Barnabè (2011).

5. Playing the "Minifabbrica Strategica" (the Strategic Micro-Firm)

5.1. The gaming context and the underlying dynamic problem

The research is based on a role playing game used in a MBA setting. The game was meant to reproduce the main operational features of a typical supply chain (SC).

As defined by Sterman (2000: 663) "a supply chain is a set of structures and processes an organization uses to deliver an output to a customer. The output can be a physical product such as an automobile, the provision of a key resource such as skilled labour, or an intangible output such as a service or product design". At the operational level, a SC can be viewed as a complex network (Dekker 2003) supporting three main typologies of flows (Akkermans *et al.* 2003: 286): m*aterial flows*, representing physical product flows from suppliers to customers; *information flows*, representing order transmission and order tracking; *financial flows*, representing credit terms, payment schedules and consignment and title ownership arrangements.

Even though the basic structure of a SC is quite simple, its overall management is not as simple, due to the underlying hierarchies, the high level of interdependence among the different actors involved and the powerful dynamics involving the complex pattern of stocks and flows that constitutes such chains. Such elements are obstacles to the fundamental aims of a SC: produce goods for the market, integrating many different firms along the SC and match customer demand with production rates and shipments.

In this regard, the literature as well as the practice have provided enough evidence of the variety of problems associated to supply chain management (SCM) interventions: in particular, very often supply chains exhibit persistent and costly instability, bottle necks and/or wide amplifications along the supply chain (the so-called "bullwhip effect"), and SCM programs are often ineffective and inefficient. Overall, SC costs can be very high and poor performance along real SCs are observed quite often.

In order to overcome such problems and improve SCM practices, many different approaches have been developed over the last decades with mixed results (Akkermans and Dellaert 2005); indeed, poor performance along real supply chains as well as incomplete understanding of their behaviour are still pressing problems for entrepreneurs, managers, employees and … students!

To this aim this research used a specific role playing game - named "Minifabbrica Strategica" - in which learners have been challenged to manage the high levels of complexity and dynamics associated to a typical SC, and accordingly design feasible SCM policies.

5.2. General features of the role-playing game

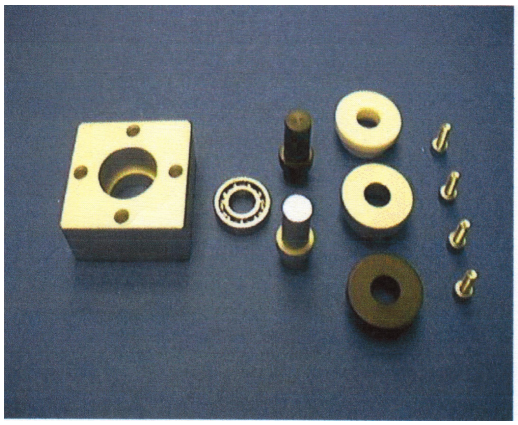
The "Minifabbrica Strategica" (i.e. "Strategic Micro-Factory", hereafter called "Micro-F"), was firstly developed by a consulting company in 2000 and has been used in a variety of training management programs afterwards.

The game reproduces the main operational features of a typical manufacturing supply chain.

The attention is placed on a specific firm (the Micro-F) that produces four different finished goods for the reference market (a routing device - similar to an axle shaft - in four different customizations).

Each finished good is made of 5 different raw materials that are assembled together: 1 base; 1 bearing (a small cushion); 1 pin; 1 cover; 4 screws.

Figure 2 - *Main raw materials used in the role playing game.*

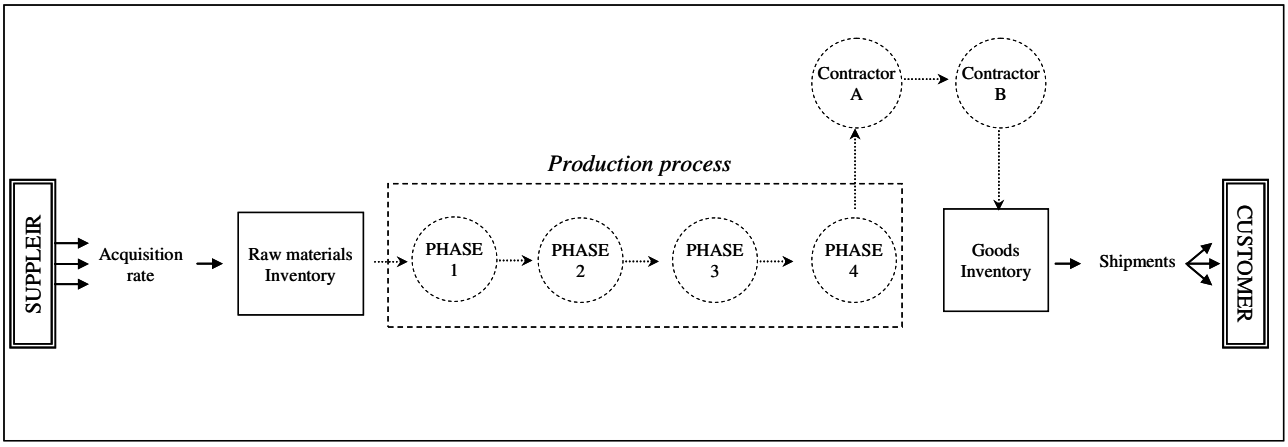


As shown above, each finished good can be manufactured in different ways, having the customer the chance to place his/her orders asking for a number of different customizations (e.g. there are two typologies of pins that can be asked for).

In its basics, the simulated SC integrates a supplier, the Micro-F and a customer. The internal Micro-F SC is structured in 6 phases. In order to fully assemble its products, the Micro-F also relies on two external contractors, working on specific customizations.

The overall SC can be subsequently represented as follows:

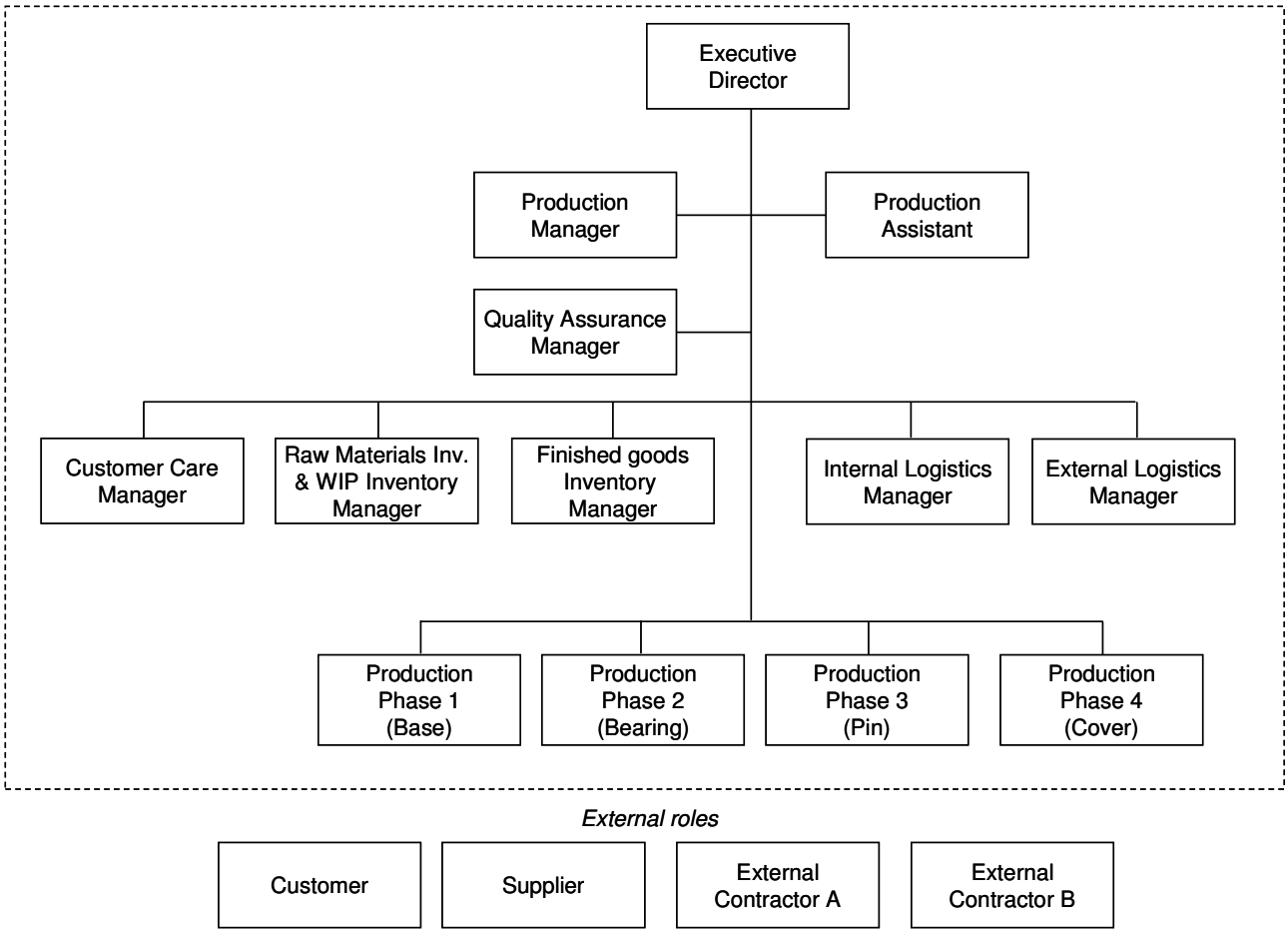
Figure 3 - *Simplified representation of the simulated SC.*



The game is played by a number of participants that can be up to 24 persons.

The main roles that the participants are required to play within the Micro-F are defined according to the following organizational chart.

Figure 4 -*Micro-F organizational chart.*



As shown, within the Micro-F the participants are called to face a role-playing situation, lively experiencing the daily working dynamics and problems characterizing any typical SC.

More in detail, the players employed by the Micro-F are assigned some specific goals to pursue:

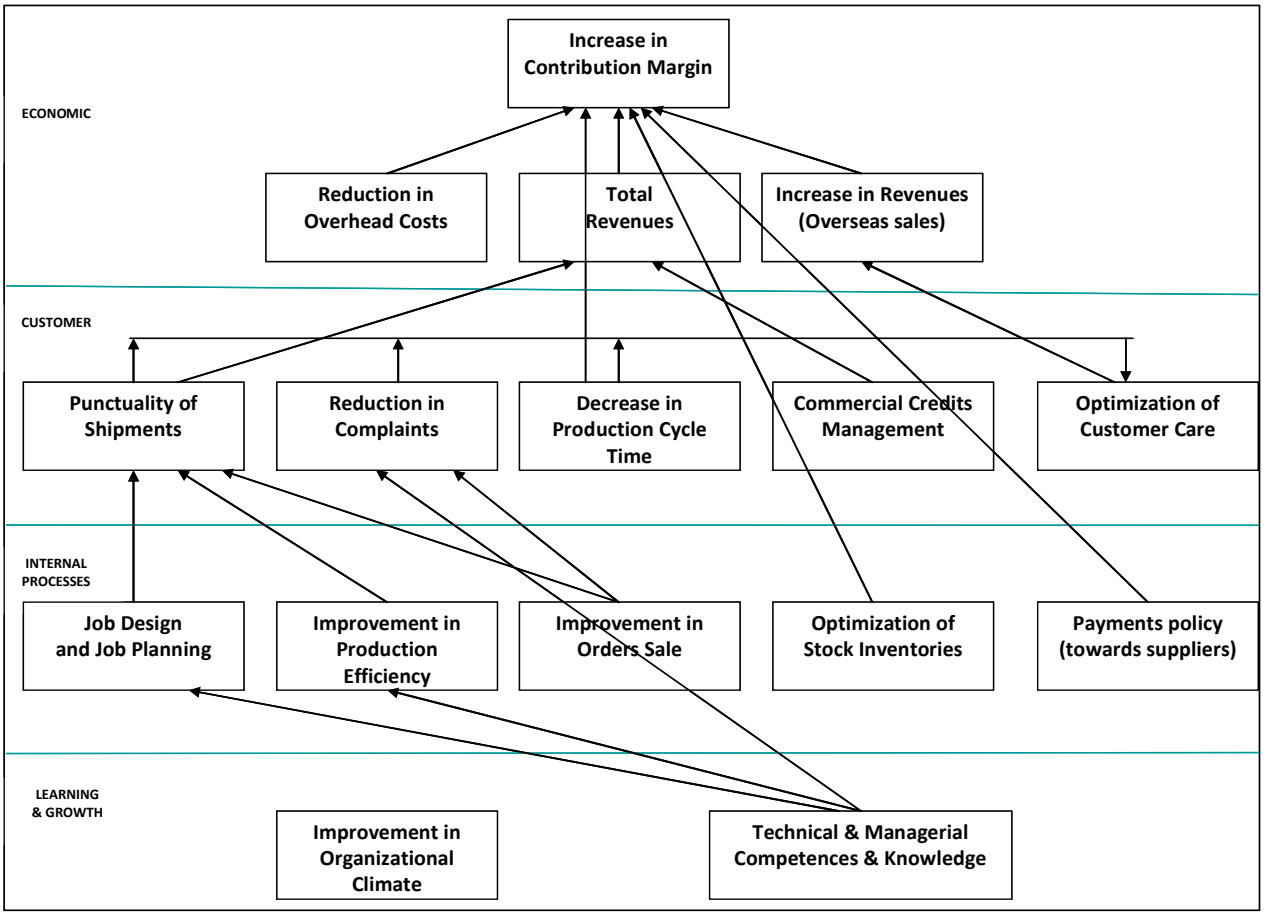
a) the Micro-F has the goal to be the leader in its reference market;
b) accordingly, all the products must be delivered to the customers on time;
c) the overall financial management of the firm should be supported by the cash flow generated through its functioning.

Starting from the previous general goals, the facilitators of the game illustrate to the participants which are the main strategic themes to be taken into consideration, as follows:

- increase firm's value;
- efficiently manage all the internal processes;
- assure a high level of customer satisfaction;
- develop internal skills over time.

Such strategic goals are consequently translated in key results and a specific mapping tools (a Strategy Map) is used to visualize the pattern of cause and effect links characterizing the Micro-F, as shown below.

Figure 5 - *Micro-F Strategy Map.*



The educational setting in which this game was played comprised master students attending a course study in management control. The following table summarises the main features of the gaming sessions.

Table 1 - *Key features of the gaming sessions.*

1	Duration of the role playing game	The overall game is played over a 2-day session. Each day includes sessions of briefing, game and debriefing.
2	The setting	Each player is assigned a specific role within the simulated SC. In the 2nd day the roles are switched among the players in order to let each participant to play both at the managerial and the operational level.
3	Time horizon of the game	12 months. Each simulated month lasts 15 "real" minutes.
4	Objectives to achieve	Deliver goods on time. Maximise customer satisfaction. High operating profit. Increase firm's value.
5	Performance outputs	The key performance indicators (KPIs) are defined on the basis of the previous objectives. The KPIs are subsequently identified across the four perspectives of the Balanced Scorecard (Economic; Customer; Internal Processes; Learning and Growth).
6	Additional features	The game may include inconveniences, such as machinery failures. Capacity constraints are also imposed.
7	Teaching support materials	Player's guide. Micro-F organizational chart. Micro-F strategic plan. Micro-F strategy map and Balanced Scorecard reports. Teaching Note.

More insights will be subsequently discussed, presenting some typical results.

5.3. Typical results and the Balanced Scorecard

The methodology carries most of the situations that normally characterize the daily life of a company, because it:

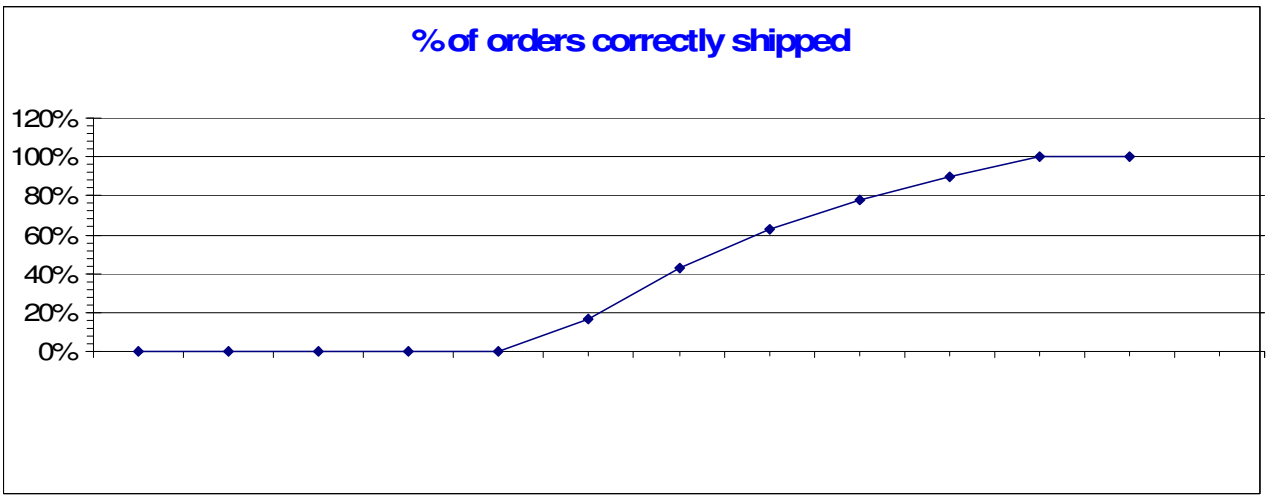
- stimulates people to cooperate in teams and think in terms of team (and not individual) goals;
- supports processes of knowledge elicitation and knowledge sharing;
- facilitates individual and organizational learning;
- allows to develop a comprehensive vision of the production process and the main features of the reference market;
- promotes the development of a trans-disciplinary professional approach to SCM;
- helps to bridge the gap between knowledge and action, facilitating the ability to transfer know-how to real working situations.

Typical results from the role-playing game usually show some difficulties at the beginning of the gaming experience: the players are usually overwhelmed by the degrees of complexity and dynamics that characterize the simulated SC and face huge problems in terms of coordination and communication within their group.

An additional problem faced by the players at the beginning of the gaming experience usually relies in their incapacity to properly manage all the information and material flows moving across the SC: in this regard, the players' attitude during the first steps of the game usually leads them to "act locally ignoring the global system and its interrelationships".

As an example, the following graph shows the number of orders that were completed and shipped by the players in a specific simulation: it is clearly possible to identify an increase in performance over time after a disastrous initial stretch.

Figure 6 - *An example of players' performance during the game.*

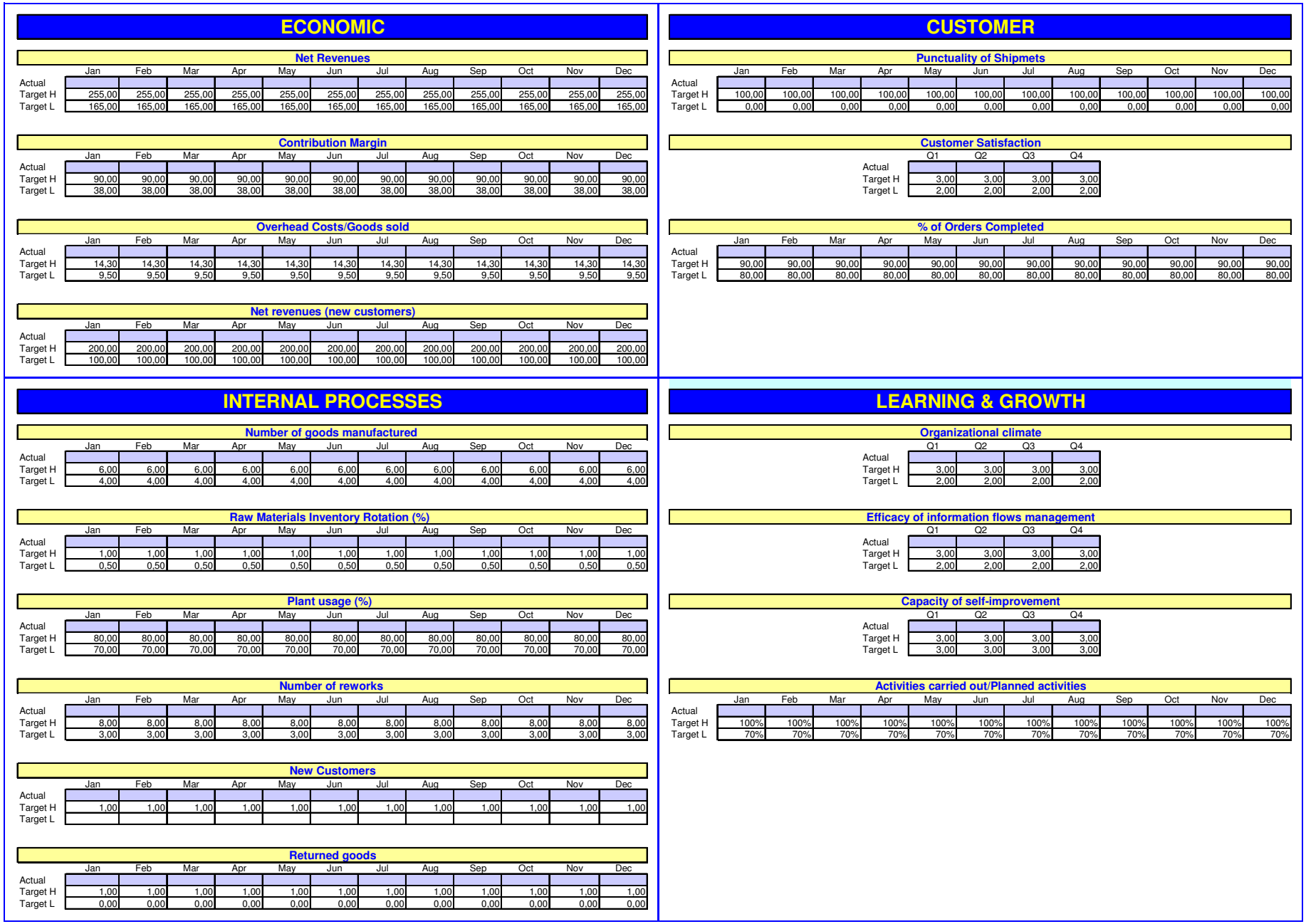


An additional difficulty usually faced by the players during the game is to correctly understand the outcomes of their actions and the systemic nature of the system they are embedded in.

Subsequently, in order to let the players make sense of the results that their actions carry out and have a more complete understanding of the system under investigation, two more phases are planned within the project.

First of all, a specific performance measurement system (the Balanced Scorecard) is used in order to register, monitor and evaluate participants' performance during the different phases of the game. The BSC cockpit is shown below.

Figure 7 - *Micro-F Balanced Scorecard cockpit.*



ECONOMIC

Net Revenues

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	255,00	255,00	255,00	255,00	255,00	255,00	255,00	255,00	255,00	255,00	255,00	255,00
Target L	165,00	165,00	165,00	165,00	165,00	165,00	165,00	165,00	165,00	165,00	165,00	165,00

Contribution Margin

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00
Target L	38,00	38,00	38,00	38,00	38,00	38,00	38,00	38,00	38,00	38,00	38,00	38,00

Overhead Costs/Goods sold

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	14,30	14,30	14,30	14,30	14,30	14,30	14,30	14,30	14,30	14,30	14,30	14,30
Target L	9,50	9,50	9,50	9,50	9,50	9,50	9,50	9,50	9,50	9,50	9,50	9,50

Net revenues (new customers)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	200,00	200,00	200,00	200,00	200,00	200,00	200,00	200,00	200,00	200,00	200,00	200,00
Target L	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

CUSTOMER

Punctuality of Shipmets

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Target L	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Customer Satisfaction

	Q1	Q2	Q3	Q4
Actual				
Target H	3,00	3,00	3,00	3,00
Target L	2,00	2,00	2,00	2,00

% of Orders Completed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00	90,00
Target L	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00

INTERNAL PROCESSES

Number of goods manufactured

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00
Target L	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00

Raw Materials Inventory Rotation (%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Target L	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50

Plant usage (%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00	80,00
Target L	70,00	70,00	70,00	70,00	70,00	70,00	70,00	70,00	70,00	70,00	70,00	70,00

Number of reworks

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00
Target L	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00

New Customers

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Target L												

Returned goods

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Target L	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

LEARNING & GROWTH

Organizational climate

	Q1	Q2	Q3	Q4
Actual				
Target H	3,00	3,00	3,00	3,00
Target L	2,00	2,00	2,00	2,00

Efficacy of information flows management

	Q1	Q2	Q3	Q4
Actual				
Target H	3,00	3,00	3,00	3,00
Target L	2,00	2,00	2,00	2,00

Capacity of self-improvement

	Q1	Q2	Q3	Q4
Actual				
Target H	3,00	3,00	3,00	3,00
Target L	3,00	3,00	3,00	3,00

Activities carried out/Planned activities

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual												
Target H	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Target L	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%

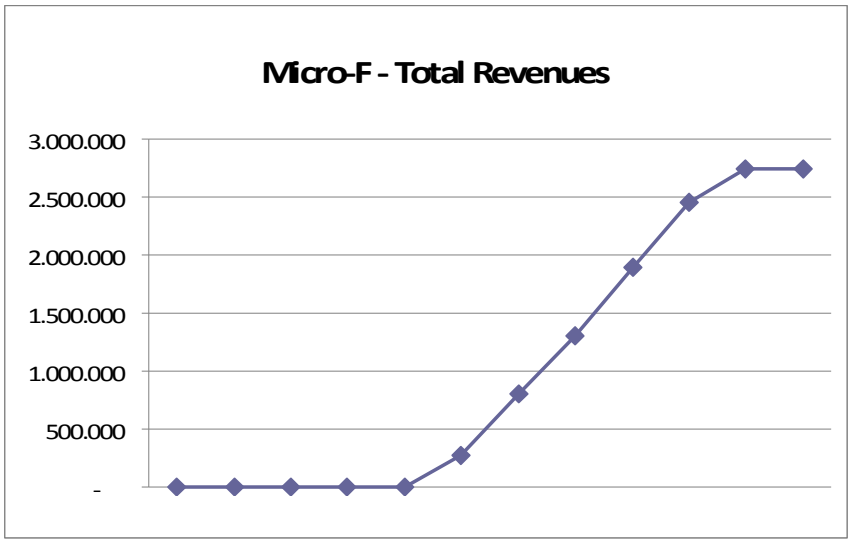
The use of the BSC allows the players to grasp the sense of their actions, continuously monitoring their performance and improvements.

Most important, the use of the BSC allows the players to identify the main cause-effect links within the simulated business domain, and understand which are the leverage points within the system under analysis, subsequently defining better policies and developing improved forms of coordination and cooperation within their teams.

Thus, relying on the data and information provided by the BSC, the players usually show the capacity to improve their performance over the two days of gaming. In this regard, typical results show steady improvements as simulation time progresses: the initial conditions of poor performance, bottle-necks along the SC and low customer satisfaction, are substituted by an overall improvement and better financial results.

Even more relevant is the fact that players become able to improve their performance in relation to all the key results (and key performance indicators) monitored within the game, as the graph below shows in reference to total revenues:

Figure 8 - *An example of players' performance (total revenues).*



The final step of the process requires to support the players in fully understanding the systemic structure of the business domain which is investigated and accordingly designing feasible SCM policies. To do that, the last phase of the project, starting from the outcomes of the debriefing, leads to a System Dynamics modelling intervention.

5.4. Debriefing and System Dynamics modelling intervention

In most of the cases, the debriefing leads to the identification of three specific underlying causes for the participants' poor performance and overall management inefficiencies: a) incomplete understanding of the cause-effect linkages across the SC, b) the complex structure of the SC and c) a lack of collaboration and coordination among the players.

More details are provided below.

a) Incomplete understanding of the cause-effect linkages across the SC.

A role-playing game based on the functioning of a complex SC is not as easy to play as it may seem. Participants are catapulted into a gaming experience where they feel the pressure and the stress generated by time, financial and material constraints. Moreover, they are pushed to make

decisions very quickly, continuously reacting to external factors, such as market demand and customer (dis)satisfaction. The overall experience requires a definite effort to cooperate and communicate, even though information are not fully available at the beginning of the game (the BSC outcomes are communicated only at the end of each simulated quarter) or are not always fully understood.

b) Complexity of the SC structure.

The structure that is typical to many SCs mostly contributes to the creation of bottle-necks and oscillations along the chain. In particular, the presence of information and material delays tends to aggravate the generation of huge amplifications.

c) Lack of collaboration and coordination among the players.

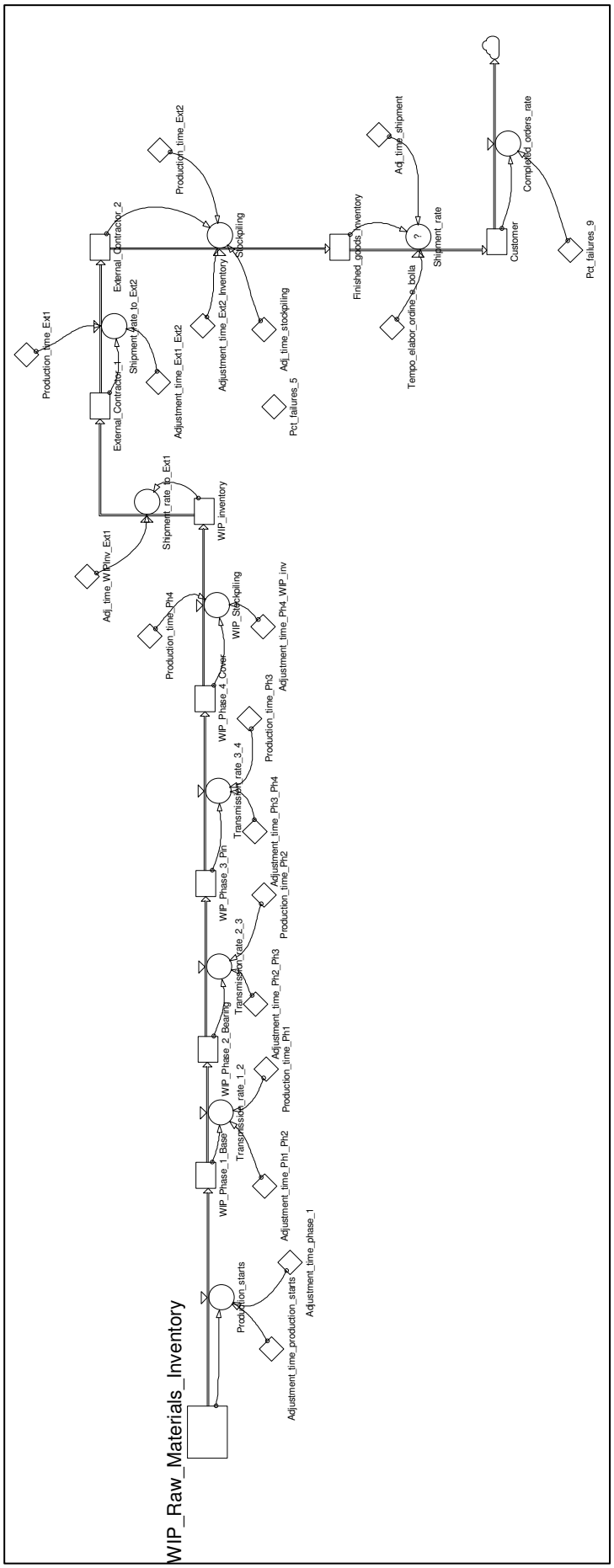
A lack of cooperation and collaboration, local optimisation, cost optimisation and performance maximisation, and are key causes for inefficiencies along real (and simulated) SCs, and for the generation of huge amplification and oscillations.

All these underlying problems are strictly interconnected and are direct consequence of a simple but at the same time powerful principle: *structure generates behaviour* (Spector and Davidsen 1997: 132); subsequently, bottle-necks and fluctuations along the SC are endogenously generated due to the specific operational features of the game and the strategies developed by the players. Moreover, poor performance and results in terms of customer satisfaction and financial outcomes directly depend on the inability to correctly manage the material and information flows that internally characterize the simulated SC.

Starting from these considerations, the final part of the debriefing aimed at further eliciting individual knowledge and conceptualizing collective learning (Ford and Sterman 1998) to later build a stock and flow diagram and a running System Dynamics simulation model (with the aim to subsequently assist players in developing SCM policies).

The first step in conceptualizing the model consisted in correctly identifying the main stock variables within the system under analysis, as shown below in this simplified representation of the Micro-F SC.

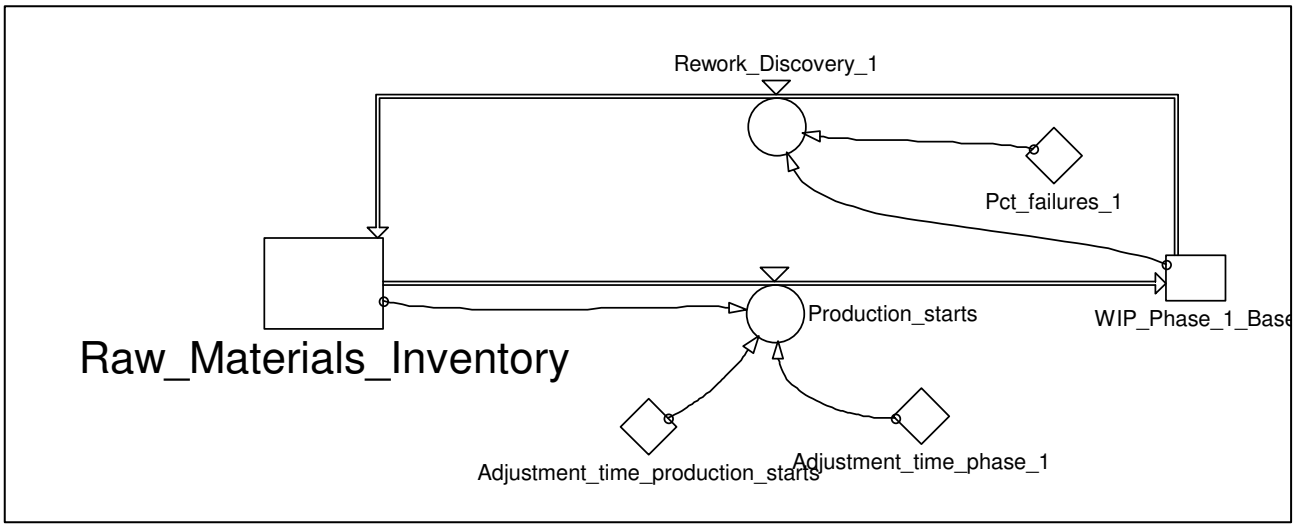
Figure 9 - *Main stock variables within the Micro-F SC.*



In each phase, production progresses depending on the time needed to transfer WIP from one stage to the other and the time needed to complete that specific production task. If a phase is correctly done, the WIP is transferred to the next production phase, otherwise (in case of poor quality or failure) it is returned to the raw materials inventory where the WIP is disaggregated.

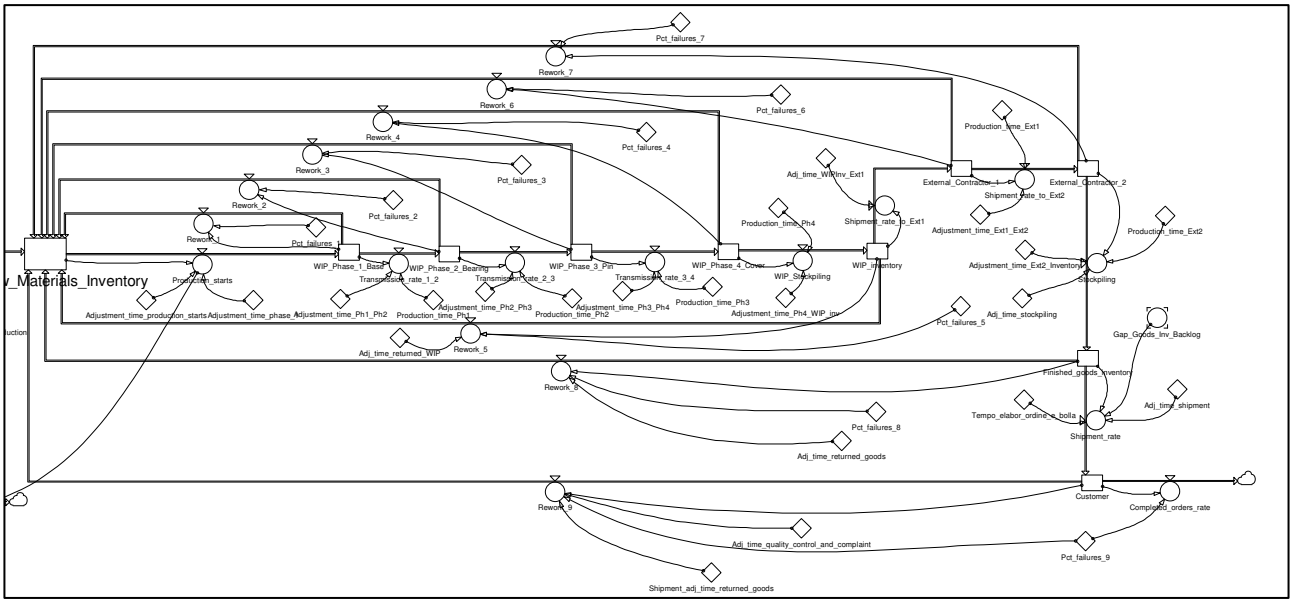
Moreover, considering the functioning of the simulated manufacturing SC, it was possible to immediately identify several negative feedback loops displaying a typical *rework cycle* (as also highlighted by Sterman 2000: 58), as shown below:

Figure 10 - *Part of the stock and flow diagram centered on the Micro-F SC.*



Starting from the previous maps and using a specific set of initial conditions for all the variables, it was subsequently possible to develop a System Dynamics simulation model able to address the fundamental challenges faced by the players during the role-playing experience.

Figure 11 - *Section of the System Dynamics model centered on the main components of the Micro-F business domain.*



Subsequently, the running model may be used to analyse the initial conditions of the game, explore alternative behaviors and assist players as well facilitators to identify and discuss feasible managerial policies for the specific SC.

Some additional remarks on the project and some comments provided by the participants are reported subsequently.

5.5. Judging the success (or failure) of the project

At the end of the gaming and modelling experience, the facilitators tried to gauge the level of the participants' satisfaction. In this regard, it is possible to state that the gaming experience, the use of the BSC and the SD modelling intervention helped to shed some light on the production process under analysis and clarify some issues related to policy making in SC contexts.

In general, trying to evaluate the outcomes of the project, the authors thought to directly quote some of the comments made by the participants at the end of the 2nd day.

"Learning from the experience is the most effective way ... I have understood that sometimes the theory does not fit with the «real working life». At the beginning it was traumatic, I did not expect to really work today ... instead I have understood that the way to a deeper learning is doing and making something concrete, and that the mistakes are one of the main sources that we have in order to learn".

"The panic I felt during the Pre-game, when we were moving like «free dogs» without roles and rules, has allowed us to recognize the importance of the organization and of the team dynamics in order to obtain good results".

"Listening and putting ideas together has contributed to improve the flow of the materials".

"I have understood the importance of the roles, of the behaviours and of the mechanisms that a company puts in action in order to catch up tasks [...] I also realized which are the problems that we can create to our customers when we sell them products and services of insufficient quality".

"The Micro-F allows you to really understand how a company works. We all have experimented that working together allows us to obtain greater results … but if I compare the various roles that I have covered in the Pre-game and the Game, I can confirm to have understood one important thought: during the Pre-game, as an operator I took personal care of the lacked arrival of the materials, I understood that something did not work well, but I was not involved in the decisional process and I could not do anything about that; in the Game, as a Program Manager, I did not have any contact with the manual operations and I felt sort of penalized ... In sum: I realized that very often we lose opportunities because we do not know how to be involved and how to listen to others".

In addition, it is to underline that the use of the Balanced Scorecard was seen as an important support for a deeper understanding, since:

- it helped to give a meaning to the participants' conduct;
- focused players' attention on a limited number of KPIs, also helping them to understand the outcomes of the actions carried out;
- stimulated a problem-solving attitude, allowing to better identifyi the causes underlying poor performance and the leverage points within the simulated environment;
- clarified which were the main linkages across the four perspectives of the BSC;

- facilitated the interpretation of the roles played during the game, in reference to the given objectives and aims.

Finally, it is also to note that the overall project led the participants to question and challenge their mental models and their assumptions about complex SC. In particular, during the debriefing phase, it was clear that the gaming experience helped the players to conceptualize the main lessons learnt and develop/suggest feasible SCM policies as well as identify new tools and devices to be implemented in order to increase efficiency and performance along typical SCs, as follows:

- improve information and communication flows;
- introduce specific inventory management policies;
- improve integration through the use of IT tools, such as ERP systems;
- use specific performance management systems, such as the Balanced Scorecard, in order to monitor performance over time and the discrepancies between targets and actual values;
- use advanced analytical tools (e.g. a simulation model) to better understand the pattern of cause-effect links within the system and identify leverage points.

It is interesting to note that some of the proposals/ideas/policies identified by the participants are mentioned by the literature as feasible solutions to SC problems and for improved SCM practices (e.g. see Towill 1996; Akkermans *et al.* 2003; Akkermans and Dellaert 2005; Granlund and Mouritsen 2003; Gunasekaran *et al.* 2004; Bhagwat and Sharma 2007).

6. Final remarks

This paper focused on the potentialities of role playing games in management education programs when in need to analyse complex and dynamic business environments. When analysing and managing such domains, traditional methods of learning and education are no more sufficient: on the contrary, there is an increasing need of new approaches, methodologies and tools, able to provide the bases for concrete experience, reflective observation, abstract conceptualisation and active experimentation.

It is authors' opinion that role playing games may have great relevance in this context: providing free risk and safe environments in which participants are called to interact with a simplified representation of a real working system, at the same time facing complex business problems, role playing games may be effective learning and training tools.

More specifically, in relation to management education, the aims pursued by role playing experiences are those of transferring skills to the students both in theoretical and practical terms, supporting them to:

- develop problem-solving skills needed to operate within environments characterized by high dynamics and complexity;
- make an appropriate use of analytical tools;
- develop system thinking skills.

Taking into account these considerations, the data and information reported in this article highlighted the benefits of using role playing games in order to sustain knowledge elicitation and knowledge acquisition in and about complex systems, and support participants to identify key leverage points within a SC, accordingly SCM policies[3].

[3] In this regard, it is also relevant to note that when engaged with role playing games reproducing very closely real working conditions, through the gaming process participants can develop an understanding of the process under analysis without being overwhelmed by the complexity of their real-life working places.

In particular, a matched use of role playing and System Dynamics simulations might play a crucial role in processes of knowledge elicitation, acquiring and sharing, since these tools provide not only a simplified representation of reality but also a meaningful context in which reflection, analysis, investigation and learning can be stimulated and may occur.

Moreover, using the Balanced Scorecard as the main reference reporting system, the players have the chance to continuously analyse and evaluate their performance and the outcomes of the actions carried out, better identifying the underlying systemic structure of the business domain under investigation.

It is our opinion that the overall approach here presented (the gaming experience plus the use of a specific performance measurement system - the BSc - and a System Dynamics modelling intervention) helped the participants and the facilitators to reach the educational goals pursued with the project.

In addition, we emphasise that the use of the “Strategic Micro-Factory” is complementary to other traditional tools and educational approaches to management training, however being very specific in focusing on the ability to transfer a “useful operating knowledge”" in a persistent way.

References

Akkermans H. and Dellaert N. "The rediscovery of industrial dynamics: the contribution of system dynamics to supply chain management in a dynamic and fragmented world", *System Dynamics Review*, Vol. 21 No. 3, 2005, 173-186.

Akkermans H.A. and Van Oorschot K.E. "Relevance assumed: a case study of balanced scorecard development using system dynamics", *Journal of the Operational Research Society*, Vol. 56 No. 8, 2005, 931-941.

Akkermans H.A., Bogerd P., Yűcesan E. and van Wassenhove L.N. "The impact of ERP on supply chain management: Exploratory findings from a European Delphi study", *European Journal of Operational Research*, Vol. 146 No. 2, 2003, 284-301.

Argyris C. *On Organizational Learning,* reprinted, Cambridge: Blackwell Publishers, 1993.

Barnabè F. "A «System Dynamics-Based Balanced Scorecard» to Support Strategic Decision Making: Insights from a Case Study, *The International Journal of Productivity and Performance Management*, Vol. 60, No. 5, 2011, 446-473.

Berggren C. and Söderlund J. "Rethinking project management education: Social twists and knowledge co-production", *International Journal of Project Management*, Vol. 26 No. 3, 2008, 286-296.

Bhagwat R. and Sharma M.K. "Performance measurement of supply chain management: A balanced scorecard approach", *Computers & Industrial Engineering*, Vol. 53 No. 1, 2007, 43-62.

Bianchi C. and Montemaggiore G.B. "Enhancing strategy design and planning in public utilities through "dynamic" balanced scorecards: insights from a project in a city water company", *System Dynamics Review*, Vol. 24 No. 2, 2008, 175-213.

Capelo C. and Ferreira Dias J. "A system dynamics-based simulation experiment for testing mental model and performance effects of using the balanced scorecard", *System Dynamics Review*, Vol. 25 No. 1, 2009, 1-34.

Chua, A. "Knowledge sharing: a game people play", *Aslib Proceedings*, Vol. 55 No.3, 2003, 117-129.

Crookall D., Oxford R.L. and Saunders D. "Towards a reconceptualisation of simulation: From representation to reality", *Simulation/Games for learning*, Vol. 17 No. 4, 1987, 147-171.

Dekker H.C. "Value chain analysis in interfirm relationships: a field study", *Management Accounting Research*, Vol. 14 No. 1, 2003, 1-23.

Elgood C. *Handbook of Management Games and Simulation*, 6th ed., Aldershot: Gower Publishing, 1997.

Ford D. and Sterman J.D. "Expert knowledge elicitation for improving mental and formal models", *System Dynamics Review*, Vol. 14 No. 4, 1998, 309-340.

Forrester J.W. *Industrial Dynamics*, Cambridge, Massachusetts: The M.I.T. Press, 1961.

Gentry J.W. *Guide to Business Gaming and Experiential Learning*, New York, NY: Nichols / GP Publishing, 1990.

Graham A.K., Morecroft J.D.W., Senge P.M. and Sterman J.D. "Model-supported case studies for management education", *European Journal of Operational Research*, Vol. 59 No. 1, 1992, 151-166.

Granlund M. and Mouritsen J. "Introduction: problematizing the relationship between management control and information technology", *European Accounting Review*, Vol. 12 No. 1, 2003, 77-83.

Gunasekaran A., Patel C. and McGaughey R.E. "A framework for supply chain performance measurement", *International Journal of Production Economics*, Vol. 87 No. 3, 2004, 333-347.

Kaplan R.S. and Norton D.P. "The Balanced Scorecard: Measures That Drive Performance", *Harvard Business Review*, Vol. 70 No. 1, 1992, 71-79.

Kaplan R.S. and Norton D.P. *The Balanced Scorecard: Translating Strategy into Action*, Boston (MA): Harvard Business School Press, 1996.

Kaplan R.S. and Norton D.P. "Having Trouble with Your Strategy? Then Map It!", *Harvard Business Review*, September-October, 2000, 167-176.

Kaplan R.S. and Norton D.P. *The Strategy-Focused Organization: How Balanced Scorecard Companies Thrive in the New Competitive Environment*, Boston (MA): Harvard Business School Press, 2001.

Kaplan R.S. and Norton D.P. *Strategy Maps: Converting Intangible Assets into Tangible Outcomes*, Boston (MA): Harvard Business School Press, 2004.

Kim D.H. "The Link between Individual and Organizational Learning", *Sloan Management Review*, Vol. 35 No. 1, 1993, 37-50.

Kolb D.A. *Experiential Learning: Experience as the Source of Learning and Development*, Englewood Cliffs, NJ: Prentice-Hall, 1984.

Lewin K. *Field Theory in the Social Sciences*, New York, NY: Harper and Row, 1951.

Lewis M.A. and Maylor H.R. "Game playing and operations management education", *International Journal of Production Economics*, Vol. 105 No. 1, 2007, 134–149.

McKone K. and Bozewicz J. "The ISM simulation: teaching integrated management concepts", *Journal of Management Education*, Vol. 27 No.4, 2003, 497-515.

Nelson R.R. and Winter S.G. *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press, 1982.

Polanyi M. *The Tacit Dimension*, London: Routledge & Kegan Paul, 1967.

Senge P.M. *The Fifth Discipline. The Art and Practice of the Learning Organization*, New York: Doubleday-Currency, 1990.

Senge P.M., and Sterman J.D. "System Thinking and Organizational Learning: Acting Locally and Thinking Globally in the Organization of the Future", in Morecroft J.D.W. and Sterman J.D. (Eds.), *Modeling for Learning Organizations*, 1st Paperback edition, Portland, Oregon: Productivity Press, 2000, 195-216.

Smeds R. "Organizational learning and innovation through tailored simulation games: two process re-engineering case studies", *Knowledge and Process Management*, Vol. 4 No. 1, 1997, 22-33.

Spector J.M. and Davidsen P.I. "Creating Engaging Courseware Using System Dynamics", *Computers in Human Behavior*, Vol. 13 No. 2, 1997, 127-155.

Sterman, J.D. (1992), "Teaching Takes Off. Flight Simulators for Management Education", *OR/MS Today*, October, pp. 40-44.

Sterman J.D., *Business Dynamics. System Thinking and Modeling for a Complex World*, Boston: Irwin McGraw-Hill, 2000.

Tomlinson B. and Masuhara H. "Using simulations as materials development courses", *Simulation & Gaming*, Vol. 31 No. 2, 2000, 152-168.

Towill D.R. "Industrial dynamics modelling of supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 26 No. 2, 1996, 23-42.

Vennix A.M.J., *Group Model Building. Facilitating Team Learning Using System Dynamics*, Chichester: John Wiley & Sons, 1996.

Wirth, I. (1992), “Project-management education: current issues and future trends”, *International Journal of Project Managementi*, Vol. 10 No. 1, pp. 49-54.