Double Learning and Performance Improvement with the Balanced Scorecard – A Simulation Based Experiment

Carlos Capelo
PhD Student
ISCTE
Ald. Vale S.Gião, 50, 2665-381 Milharado, Portugal
Phone: +351962831740
carlos.capelo@galpenergia.com

João Ferreira Dias
Associate Professor
ADETTI/ISCTE
Av das Forças Armadas, 1649-026 Lisboa, Portugal
Phone: +351938450825
fdias@iscte.pt

Abstract

Kaplan and Norton propose a double-loop process that integrates the concepts of Balanced Scorecard and Strategy Map to support managers to define and implement the firm strategy more effectively. The BSC is a performance management system based on a set of few and critical indicators. These key performance indicators are linked together in a causal diagram that represents the hypotheses about the strategy.

This approach supports what Argyris calls double-loop learning which facilitates the strategic learning of managers and leads to better performance. This type of learning produces changes in manager assumptions about cause-and-effect relationships and leads to a better understanding of the context, what means a process by which managers can explicit and improve their mental models about the business system.

This article describes a simulation-based research for testing a system of hypotheses about the influence of the BSC approach on strategic learning and performance, which uses a System Dynamics-based micro world.

Key words: Balanced Scorecard, Simulation Experiment, Double Learning, Mental Model, System Dynamics

1. Improving Double-Loop Learning and Performance with the BSC approach

The Balanced Scorecard Approach

Kaplan and Norton (1992, 1996a) introduced the Balanced Scorecard (BSC) with the aim to overcome some strategic management limitations of the traditional performance measurement systems that were based mainly on financial measures. In this approach a mix of lead (performance drivers) and lag (outcome measures) indicators, and of financial and non-financial measures, are balanced in four perspectives (financial, customer, process and, learning and growth) to help managers to simultaneously monitor the financial performance, evaluate the results of short-term actions that drive future financial performance and the progress of the strategy implementation.

According to the authors, the Balanced Scorecard describes top managers a picture of a possible future (vision), a path for getting there (strategy) and its translation in middle and short-term objectives and actions. However, formulating the Balanced Scorecard and linking it consistently to the company's strategy involves the understanding of the cause-and-effect relationships between performance drivers and financials in a systemic perspective of the company's context.

Since BSC was firstly introduced (Kaplan and Norton, 1992), an enormous number of books and articles that describe and recommend the BSC implementation have been published. According to Kaplan and Norton (2001a), many organizations around the world are using the BSC approach to define, implement and manage strategy. In fact, recent surveys showed that the BSC was the most popular performance measurement system, which was adopted by more than 40% of organizations worldwide - 57% in UK, 46% in USA, 28% in German and Austria - (Rigby, 2001; Speckbacher et al., 2003).

To support managers to build a cause-and-effect perspective and to better understand the business system they are embedded in, some years later, Kaplan and Norton (2000, 2001a) developed the Strategy Map concept as a complementary tool of the BSC approach. The strategy map links the performance indicators in a causal chain (causal diagram) that helps managers to translate, test and communicate their understanding about the business system and supports them to implement and review the company's strategy. Kaplan and Norton (2001a, p10) define a strategy map as "a logical comprehensive architecture for describing strategy. It provides the foundation for designing a Balanced Scorecard that is the cornerstone of a strategic management system."

The BSC approach is consistent with the systemic and dynamical view of business management and performance measurement (Warren, 2002). This framework recognizes the interconnectedness within the business and the importance of understanding the cause-and-effect relationships and its dynamics as a consistent basis to infer future performance and define objectives and action plans. Strategy maps, combined with balanced scorecards, provide an integrated and holistic approach to business management and performance measurement. The strategy map describes manager perception about the structure of the business system and the performance measurement information from BSC captures the essential of system behaviour. In this perspective, Kaplan and Norton suggested that "the BSC can be captured in a system dynamics model that provides a comprehensive, quantified model of a business's value creation process" (Kaplan and Norton, 1996b, p67).

We can find few literatures that point out some problems and limitations of the BSC approach. Norreklit (2000, 2003) provide critical examinations of the BSC assumptions and concepts. The inadequate definition and utilization of the performance indicators has been pointed out as a main cause of the failure of the BSC adoption (Lingle and Schiemann, 1996; Stivers et al., 1998; Ittner and Larcker,1998; 2003; Olve et al., 2000).

In particular, Ittner and Larcker (2003) reported that only 23% of 157 organizations surveyed, consistently build and test causal models to support the definition of the performance indicators, but these organizations achieved on average better performance. Akkermans and van Oorschot (2002) point out some limitations on the BSC conception and propose a methodology based on System Dynamics tools. Ittner et al.(2003) didn't find relevant performance implications of the BSC utilization. Braam and Nijssen (2004) found that BSC use that complements company strategy positively influenced the company performance, while the performance effect of a measurement-focused-BSC use was significantly negative. The results of simulation-based experiments reported by Strohhecker (2004) suggested a negative influence of BSC utilization on performance.

Empirical research about the performance implications of the BSC process is still scarce. Companies around the world continue making large investments of money, time and effort on the development and implementation of BSC systems. Considering that these investments are based on the hypotheses that the use of BSC has a positive impact on the performance of the organization, it is important to obtain some evidences whether these systems lead to an improvement of strategic learning and decision effectiveness.

Mental Models

Mental model is a conceptual representation of the structure of an external system form by people and they use them to describe, explain and predict system behavior (Craik, 1943, Johnson-Laird, 1983). Mental models have been commonly used in system dynamics and system thinking literature (Forrester, 1961; Senge, 1990; Doyle and Ford, 1998, 1999; Sterman, 2000).

Doyle and Ford (1998, 1999) defined this concept as *"- a mental model of a dynamic system is a relatively enduring and accessible, but limited, internal conceptual representation of an external system (historical, existing, or projected) whose structure is analogous to the perceived structure of that system."*

Managers build their mental models as they interact with the business system they are embedded in. Experimental research has suggested that decision makers perform better if the structure of their mental models is more similar to the structure of the external system they imitate (Kieras and Bovair, 1984; Rowe and Cooke, 1995; Wyman and Randel, 1998; Ritchie-Dunham, 2001, 2002).

Double-loop learning

Managers make decisions and learn in the context of feedback loops (Forrester, 1961). In the single-loop learning, managers compare information about the state of real system to goals, perceive deviations between desired and actual states, and make the decisions they believe will move the system towards the desired state. In this process, the information about system state is the only input to decision making. But decisions are the result of applying decision rules and policies that are in turn governed by manager' mental models (Sterman, 2000).

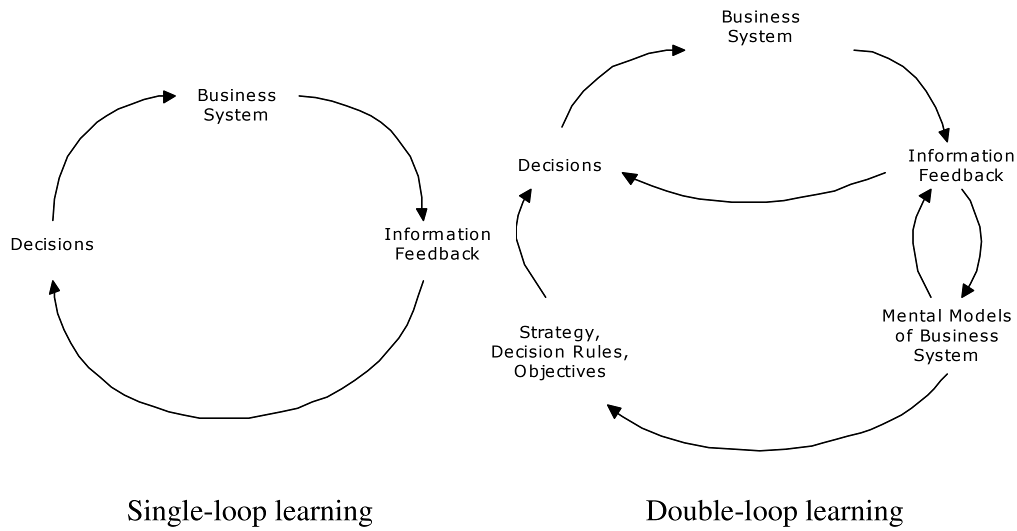


Figure 1 – Single and Double-loop learning
Source: Adapted from Sterman (2000, p19)

The single-loop learning does not change the managers' mental models. In the double-loop learning (Argyris, 1999), information about the business system is not only used to make decisions within the context of existing frames, but also feeds back to alter managers' mental models (Sterman, 2000). As their mental models change, managers define new strategies and policies (figure 1).

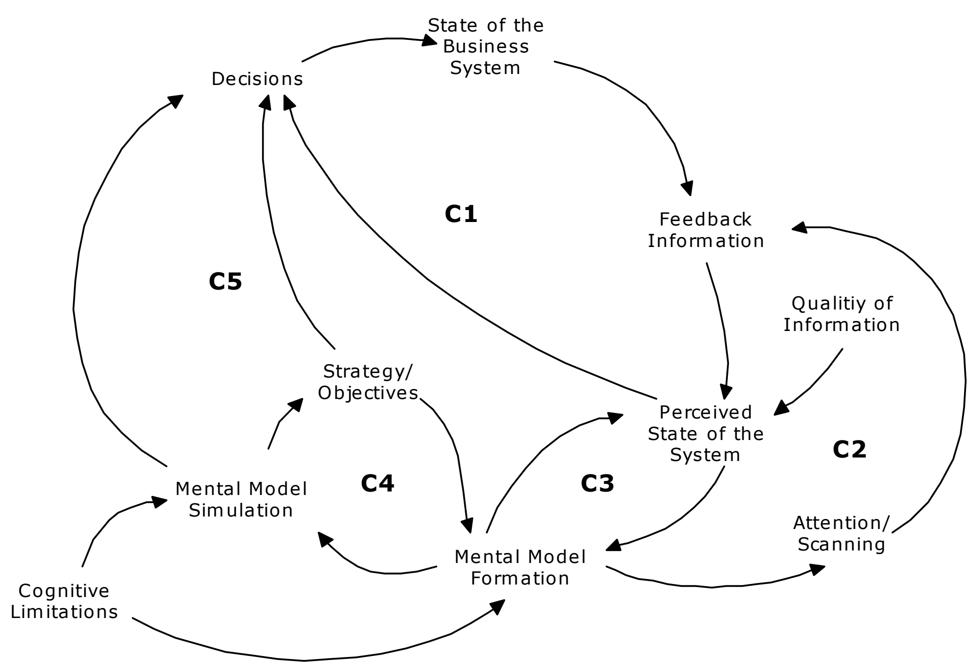


Figure 2 – Dynamic model of decision-making process
Adapted from Doyle, Ford, Radzicki and Trees (2001, p 22)

Doyle, Ford, Radzicki and Trees (2001) based their work on a dynamic model of decision-making process based on 5 feedback loops (figure 2: C1 - heuristic decision making loop; C2 - attention/scanning loop; C3 - mental model formation/ perception loop; C4 – strategy/objectives-changing loop; C5 mental model based decision making loop) where the mental models assume a central role. In that model, managers define strategy and objectives by mentally simulating their mental models about the business system.

As represented in figure 2, cognitive limitations and quality of feedback information influence the potential for strategic learning and performance by limiting managers' understanding about the real business system. Cognitive limitations are related to the bounded rationality of human decision-making (Simon, 1999). Due to limitations of cognitive capabilities, first - the mental models managers use to make their decisions are deficient – second – even managers form adequate mental models, are unable to correctly infer the dynamic behaviour of the business system (Sterman, 2000). Strategic learning process is also strongly influenced by the quality of the feedback information about the state of the business system. Managers use that information to interact with business system. Using imperfect feedback information, managers have an incorrect perception about the impact of their decisions, and so they are unable to build their mental models accurately (Sterman, 2000). Thus, performance measurement systems must be defined in order to overcome or minimize these barriers to strategic learning.

Improving Double-Loop Learning and Performance with the Balanced Scorecard approach

In the BSC framework, strategies are seen as hypotheses. Managers should be able to test, validate, and review these hypotheses. The BSC provides feedback information to managers in a way that they gain a better understanding of the business system and improve the strategy. Kaplan and Norton (2001a) propose that the BSC approach supports what Argyris (1999) calls double-loop learning that facilitates the strategic learning of the managers and leads to better performance.

Kaplan and Norton (2001b, pp152-155) describe that double-loop process of strategic learning and adapting (figure 3), using three processes, as described in figure 3: (1) Organizations use the BSC to link strategy to the budgeting process"; (2) Management meetings to review strategy are introduced; and (3)

"Finally a process for learning and adapting the strategy evolves. The initial BSC represents hypotheses about the strategy; at time of formulation it is the best estimate of the actions what would engender long-term financial success. The scorecard design process makes the cause-and-effect linkages in the strategic hypotheses explicit. As the scorecard is put in action and feedback systems begin their reporting on actual results, an organizations can test the hypotheses of its strategy." (Kaplan and Norton, 2001b, p154).

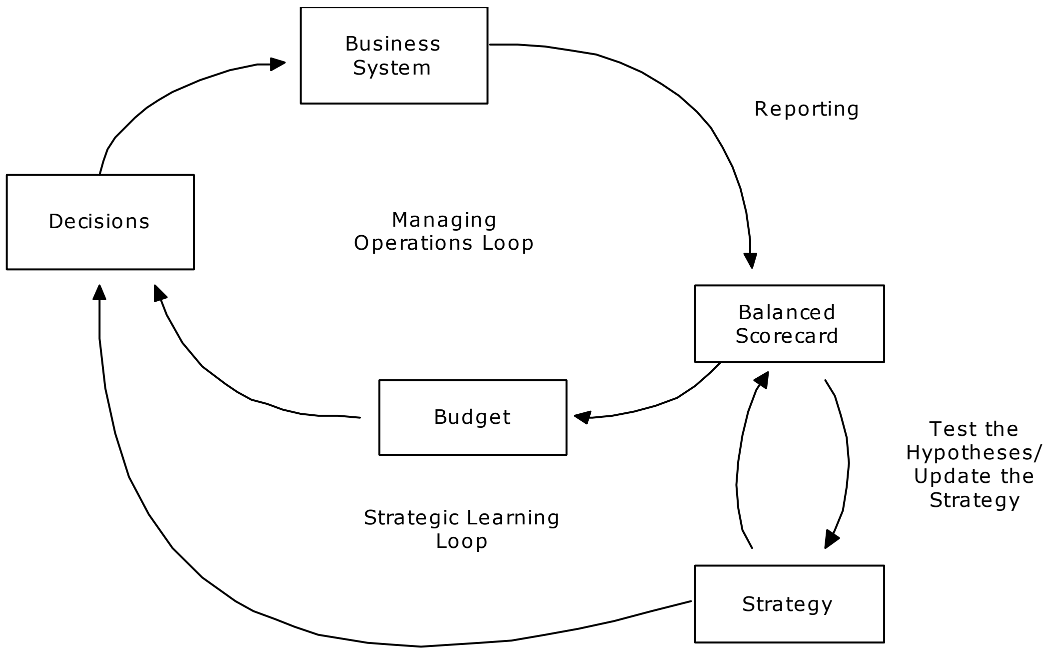


Figure 3 - Double-loop process to manage strategy

Adapted from Kaplan and Norton (2001a, p275)

In a continual process, managers use the BSC and strategy map to reflect on the assumptions that were used in the previous strategy. They review the assumed cause-and-effect relationships and identify new ones. Then they improve their understanding about the business system and a new strategy can emerge (Kaplan and Norton, 2001a, p316).

In other words, the BSC approach provides a process by which managers can make explicit and improve their mental models about the business system. They adapt the company strategy and define the new short and middle term objectives by simulating their mental models to infer the future behavior of the business system.

Some simulation-based experiments have been carried out with the aim of testing the effects of the BSC on performance. Ritchie-Dunham (2001, 2002) in a simulation-based research where subjects run a firm by interacting with a system dynamics-based micro world found that the similarity of subject's mental model positively mediated the influence between the utilization of the BSC and the performance. It means that the BSC utilization positively influenced the mental model similarity and it positively influenced the performance. The results of simulation-based experiments reported by Strohhecker (2004) suggested a negative influence of BSC utilization on performance.

2. Research Model

This research focuses on how the level of BSC approach used in the process of strategy review and implementation influences the double-loop learning effectiveness, and how this type of learning influences the management performance. To conduct the research we propose these variables and the following model of hypotheses (figure 4):

- Level of Scorecard – This variable represents the intensity or level of BSC usage as a comprehensive and balanced performance measurement system. We operationalized this variable by considering two levels. In the low level, subjects run the firm using a financial scorecard; in the high level a balanced scorecard is used;

- Level of Strategy Map – This variable represents the intensity or level of Strategy Map utilization as a tool of the BSC approach to support the process of strategy review and implementation. We defined and operationalized this variable by considering two levels. In the low level, subjects do not use the Strategy Map; in the high level, the Strategy Map is used;

- Mental Model Similarity – The level of double-loop learning effectiveness due to the process of strategy review and implementation (Kaplan and Norton, 2001a) is viewed as the improvement of manager mental models (Argyris, 1999, Sterman, 2000). Participants in the simulation task develop a mental model of the simulated business system. As we know the structure of the simulated business system, if we capture the participants' mental model, we can evaluate how it fits the simulated reality. This evaluation is based on the measurement of the similarity between the structure of the elicited mental models from the participants and the structure of the simulated business system (Rowe and Cooke, 1995; Ritchie-Dunham, 2002);

- Performance – The performance of this management task consists of the financial value created by the firm. This value is estimated by summing the yearly discounted economic profit or EVA (=NOPLAT – Capital Employed x WACC), (Copeland, Koller and Murrin, 2000, p150).

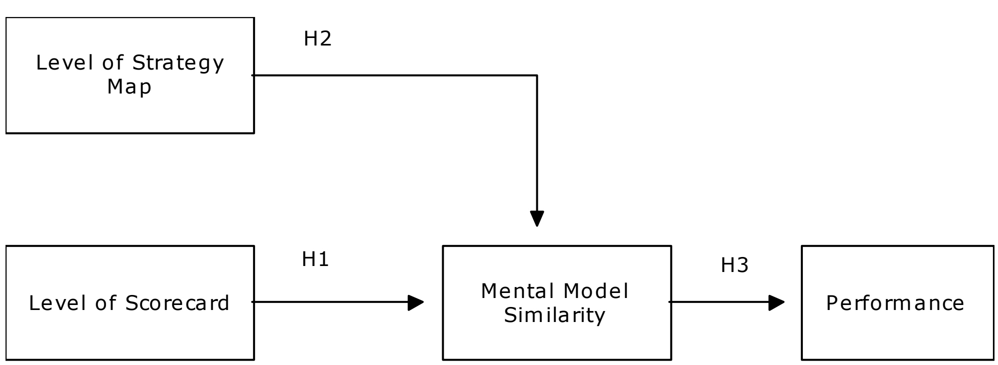


Figure 4. Model of Hypotheses

Hypotheses 1:
If managers use the balanced performance measurement system from BSC in the process of strategy review and implementation, they have a more effective double-loop learning. It means that Level of Scorecard utilization positively influences Mental Model Similarity.

Hypotheses 2:
If managers use the strategy map tool of the BSC to support strategy review and implementation, they have a more effective double-loop learning. It means that Level of Strategy Map utilization positively influences the Mental Model Similarity.

Hypotheses 3:
Mental Model Similarity positively influences Performance (financial value creation).

Hypotheses 4:
Mental Model Similarity positively mediates the effect of Level of Scorecard and the effect of Level of Strategy Map, on Performance.

3.Method

Micro World

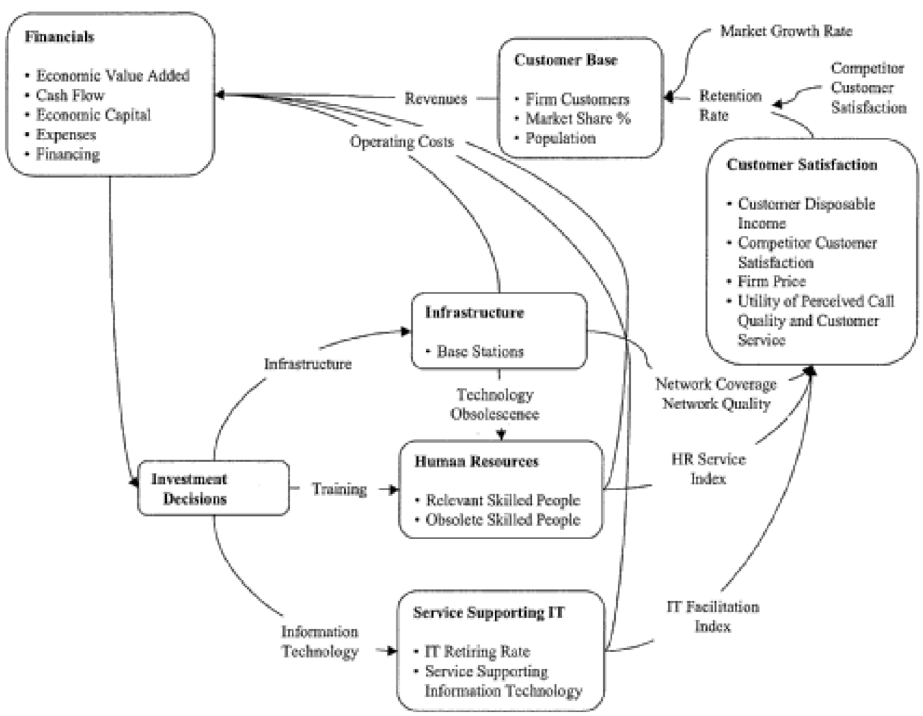


Figure 5 – Overview of the simulator model
Source: Ritchie-Dunham (2002, p22)

In this simulation-based experiment, subjects interacted with a system dynamics micro world (figure 5). We built this micro world by programming the same system dynamics model that was developed and used by Ritchie-Dunham (2002, pp 89-132), with version Studio Expert 2003 of the Powersim system dynamics software (http://www.powersim.com).

Simulation Task

In order to compare some results with those obtained by Ritchie-Dunham (2002), we designed this experiment by only making adjustments that were needed to carry out our research. We used the same business case, model' structure, game interfaces and initial conditions that were used by Ritchie-Dunham (2002). The text and simulator interfaces were translated to Portuguese.

The participants run a realistic simulator of a wireless telecommunications firm by making strategic decisions every six months for a simulation period of seven years (investment decisions in infrastructure, information technology and training, and human resource decisions) in order to maximize the value creation.

The participants interacted with simulator by two different interfaces: a financial scorecard or a balanced scorecard. The initial conditions and the structure of the model were the same for all participants. The participants were asked to make strategic decisions in order maximize the value creation.

Subjects

This research was conducted at ISCTE (a business graduate school in Lisbon) and at Galp Energia, one of the biggest Portuguese firms (the Portuguese oil company). At the ISCTE the group consisted of 14 undergraduate students in their last year of Business Degree. Their age ranged from 22 to 25 and they had no work experience. At Galp Energia the task was performed by a group of 59 managers. Their age ranged from 25 to 54 and they had an average 13 years of work experience. The simulation task was individual, anonymous and without rewards.

The participants had no experience with the simulator and they also had no prior specific knowledge about wireless telecommunications business.

Apparatus

At the ISCTE, the experiment was carried out in a computer laboratory with one participant per computer. At Galp Energia, each participant performed the simulation task in his work place using his computer.

Each participant was provided a full experiment guide with (a) demographics questionnaire; (b) description and objective of the simulation task; (c) case text; (d) instructions for accessing and starting the simulator in the computer network; (e) instructions for running the simulator; (f) questionnaire about strategy and objectives; (g) sheets for strategy map review (only for participants using strategy map); (h) questionnaire about the relatedness of some simulator variables.

The decisions made on the simulation and its results were automatically stored in a protected spreadsheet on the participant's computer. The game stopped automatically when the stop time of the simulation was reached.

Procedure

There were three different treatments:
A – The participant run the firm by using a financial scorecard
B – The participant run the firm by using a balanced scorecard
C – The participant run the firm by using a balanced scorecard and reviewing a strategy map

In the simulation experiment, the participants are involved in the following dynamical decision-making processes:

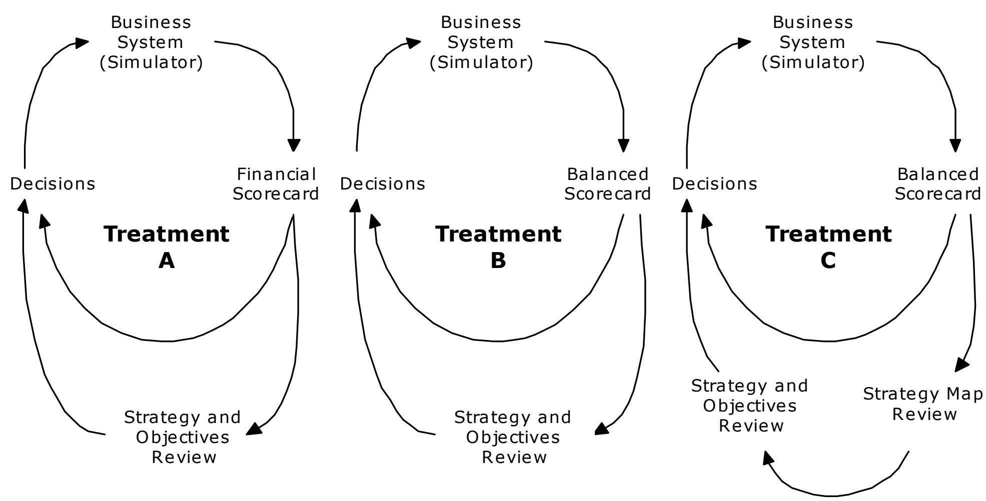


Figure 6 – Type of treatment and its dynamical decision-making process

As outlined in figures 6 and 7, treatments A and B had the same procedure. Procedure for treatment C was different from previous as participants reviewed strategy map (figures 6 and 8).

The experimental procedures had the following steps: (1) The participants are randomly assigned to one of three treatments (A, B or C); (2) The participants answered some demographic questions; (3) they read the introduction with the overall description and the objectives of the simulation task and then they read the business case study; it took approximately 30 minutes on average.

- treatment A,B – (ab4) they read the instructions for accessing, starting and running the simulator; (ab5) they ran a first quick simulation to get used to game interfaces and commands; (ab6) they ran a second and definitive simulation by making strategic decisions every six months for a period of seven years that yields fourteen decisions; during this simulation, they answered a questionnaire about strategy and objectives every 2 years of simulation time; it lasted approximately 60 minutes on average; (ab7) after the definitive simulation, the participants answered a questionnaire about their final understanding of the relatedness between some strategic variables like resources and decisions; it lasted approximately 30 minutes on average.

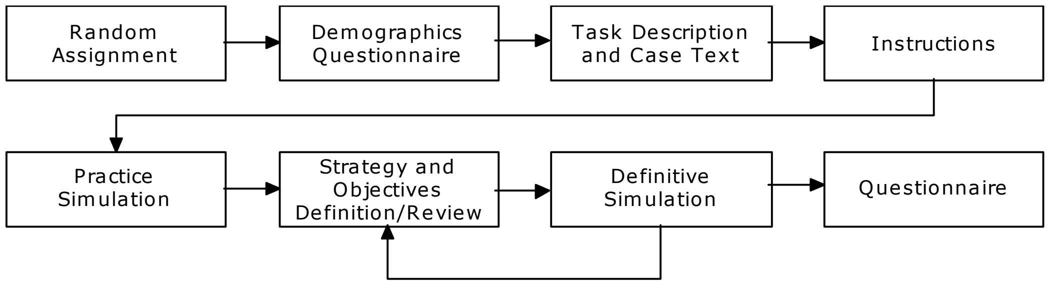


Figure 7 – Experimental procedure for participants not using the Strategy Map – Treatments A and B

- treatment C – (c4) the participants filled out the questionnaire of step ab7; this questionnaire captured their first understanding about business system; they were given an initial strategy map which was based on the results of that questionnaire (c5) step ab4; (c6) step ab5; (c7) participants performed the definitive simulation as step ab6 but in this treatment they reviewed the strategy map as well; (c8) they drafted the final strategy map; this map represented their final understanding about business system.

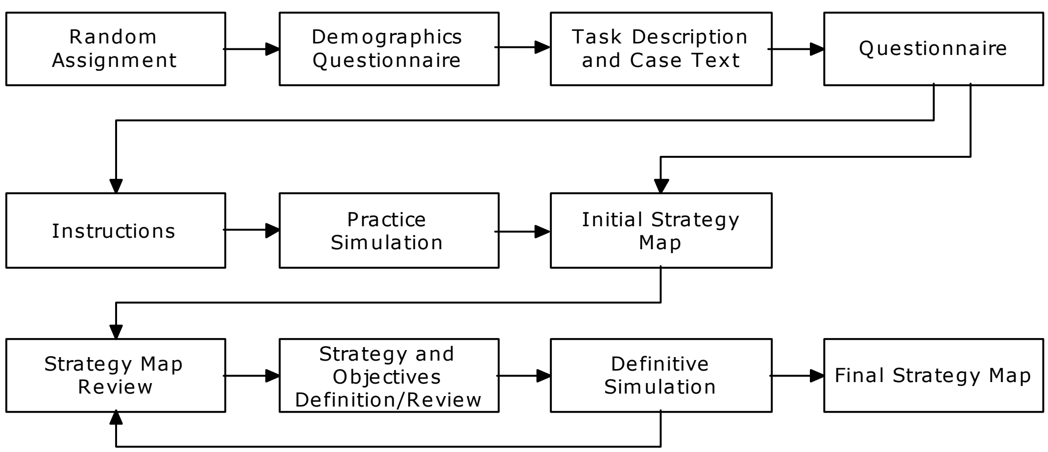


Figure 8- Experimental procedure for participants using the Strategy Map - Treatment C

Independent Variables

The research model considers two independent variables, the Level of Scorecard and the Level of Strategy Map. The Level of Scorecard was operationalized as low – participants run the simulator using a financial scorecard (figure 9) - or high – balanced scorecard (figure 10).

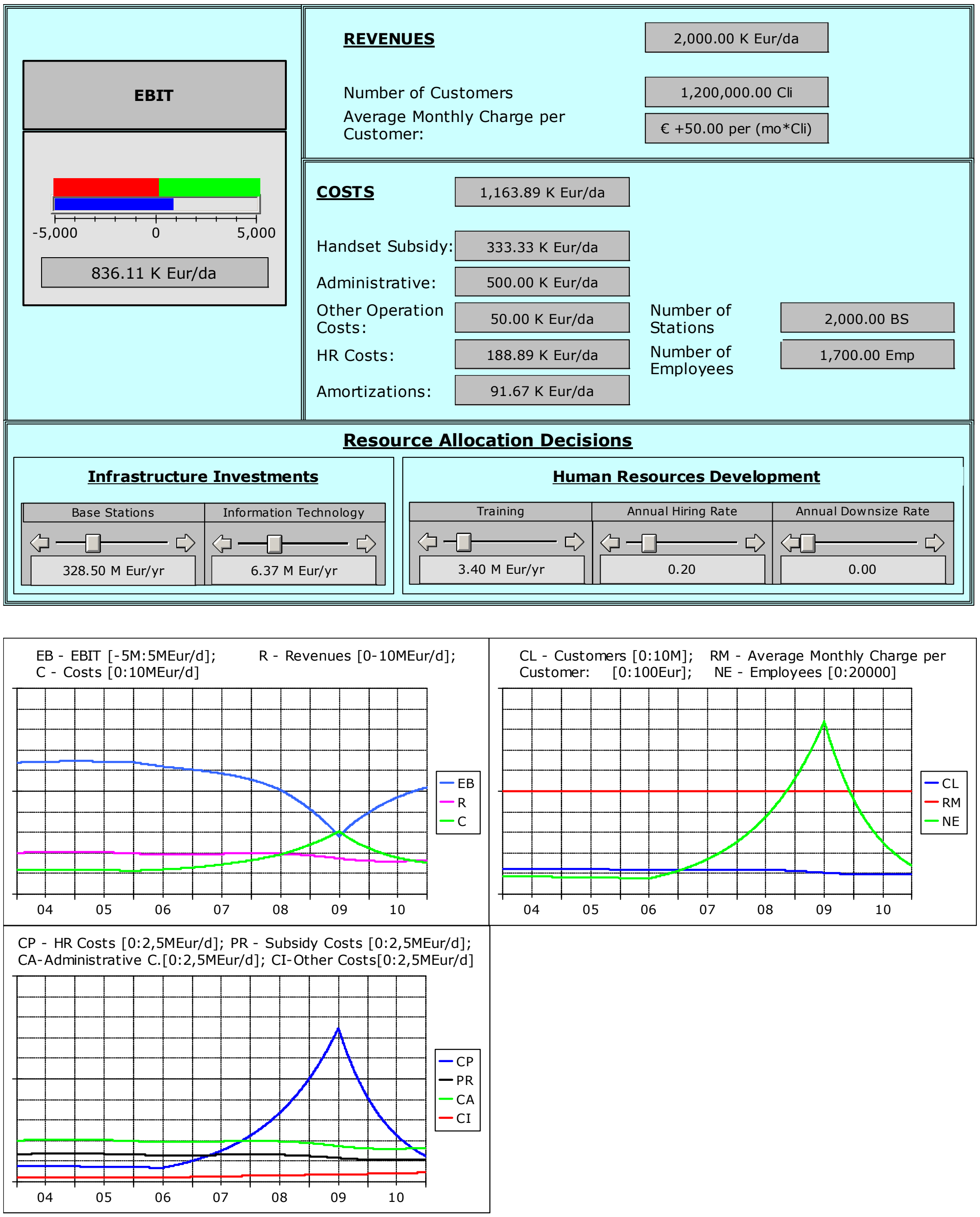


Figure 9 – Low Level of Scorecard: simulator interface with financial scorecard
Adapted from: Ritchie-Dunham, 2002, pp162-163

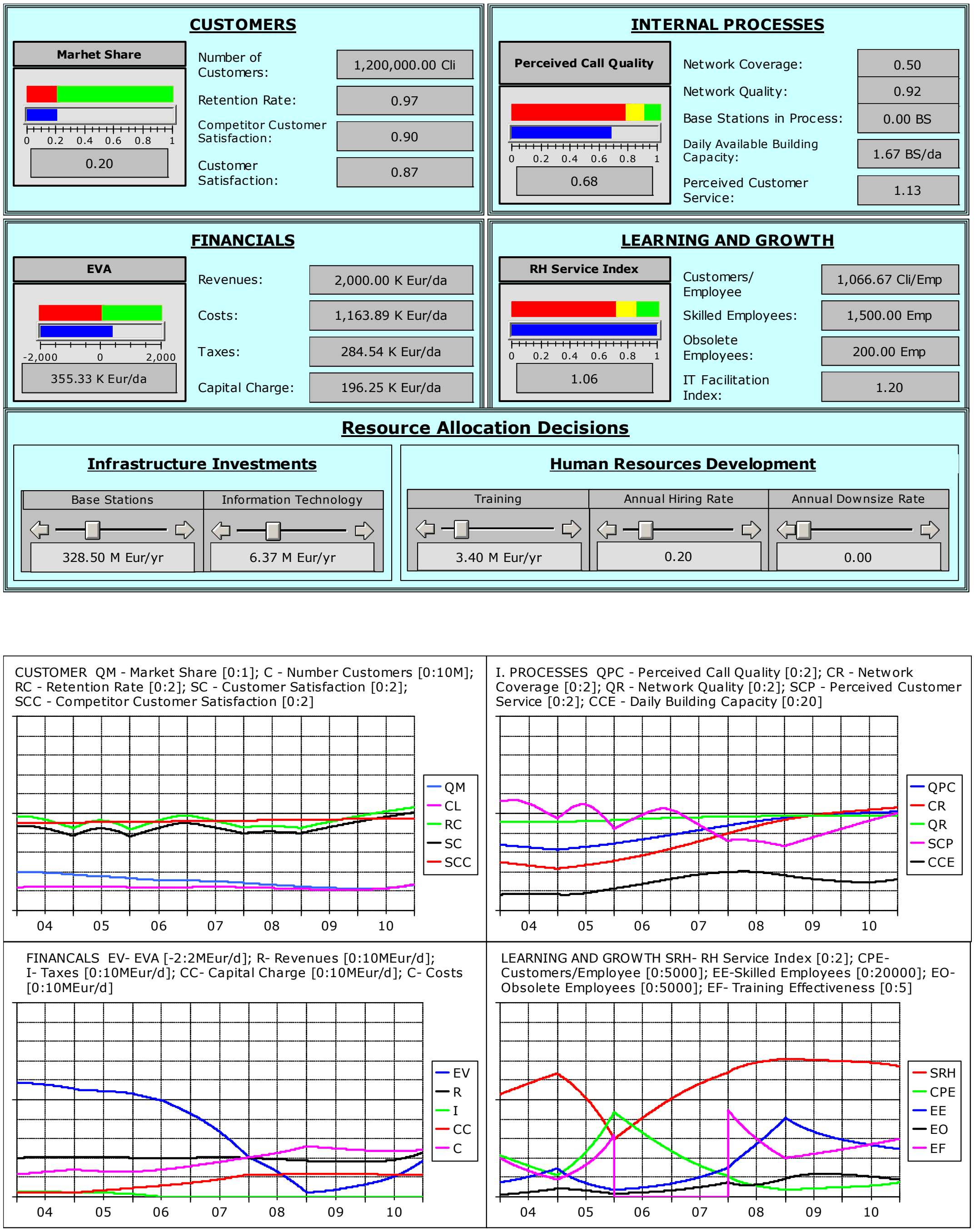


Figure 10 – High Level of Scorecard: simulator interface with balanced scorecard
Adapted from: Ritchie-Dunham, 2002, pp164-165

The financial scorecard exhibits EBIT and other measures that are directly related to its calculation (Ritchie-Dunham, 2002, pp162-163). The balanced scorecard interface graphically separates the four sections related to the four perspectives of BSC approach (Ritchie-Dunham, 2002, pp164-165).

The Level of Strategy Map was operationalized as low – participants run the simulator not using strategy map - or high – participants run the simulator by using strategy map to define and review the strategy and objectives.

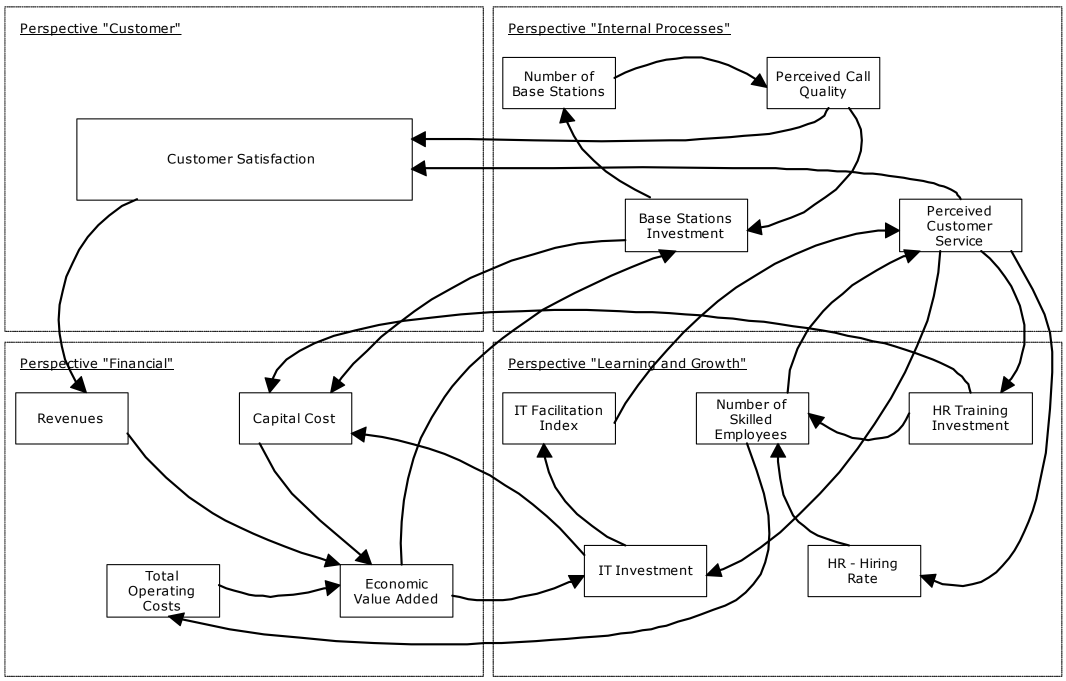


Figure 11 – High Level of Strategy Map: Example of causal diagrams participants used to review their understanding about simulated business system. This diagram also shows the representative network of the simulated business system

The strategy map (example in figure 11) that was used in this experiment consists of a causal diagram with the same variables that are considered in the questionnaire regarding to participants' initial understanding of business system. These variables are spatially organized in four set of indicators respectively related to the four perspectives of the balanced scorecard.

The answers to the questionnaire about the relatedness of variables yielded a network diagram by using the Pathfinder procedure (Schvaneveldt, 1990; Rowe and Cooke, 1995). Participants were given an initial strategy map that was drawn from the previous network diagram. This diagram represents the initial strategy that is expressed as a system of causal hypotheses. During the simulation, participants are asked to review the causal diagram. They cut or insert links so that the causal diagram expresses their last understanding about the simulated business system.

Treatment	Description	Level of Scorecard	Level of Strategy Map
A	Low LSC, Low LSM	-1	-1
B	High LSC, Low LSM	1	-1
C	High LSC, High LSM	1	1

Table 1 – Operationalization of independent variables as dummy variables

Other Independent Variables

Variable	Description
Time	Total time participants spent on task
Age	Participant age
Simulation Experience	Previous experience with management simulators (dummy variable) no previous experience: 0; previous experience: 1

Table 2 – Other Independent Variables

Dependent Variables

Mental Model Similarity represents the participants' understanding of the structure of simulated business system. This variable measures the similarity between the structure of subjects' mental models and the structure of the simulated business system (figure 11).

In the treatments A and B, after simulation participants were asked to fill out a questionnaire about their final understanding on simulated business system. In this questionnaire subjects rated on a nine-point scale, the relatedness of 14 nodes in the simulation model (Ritchie-Dunham, 2002, p65). These 14 variables are relevant to understand the simulated business system. The 91 - $(14^2 – 14)/2$ - pairings were presented in random order. The structure of participant mental' model is elicited by this pair-wise relatedness ratings technique. These elicited pairings are transformed into a network diagram using a network scaling procedure Pathfinder (Schvaneveldt, 1990).

In the treatment C, after simulation subjects produce a final strategy map which links the same 14 nodes of simulation model. This final strategy map represents the elicited structure of subjects' mental model.

Mental Model Similarity was operationalized as the similarity of these two networks - network of elicited subjects' mental model and network of the 14 nodes and related links that explain most of the structure of simulated business system (figure 11). This network similarity was measured by using the Pathfinder procedure (Schvaneveldt, 1990; Rowe and Cooke, 1995; Ritchie-Dunham, 2002). Mental Model Similarity ranges from 0 (low similarity) to 1 (high similarity) and is determined by the number of links in common divided by the total number of links in both networks.

Task performance was measured by total financial value creation. This value is estimated by summing the discounted economic profit or economic value added (=Net Operating Profit Less Amortizations and Taxes – WACC x Total Capital Employed) of the firm over the seven simulated years (Copeland, Koller and Murrin, 2000, p150).

The participants were clearly informed that the performance measurement only took into account the value added of the firm and so the firm continuing value would not be taken in consideration. This condition forced participants to better balance decisions in developing strategic resources.

Specific Variables of Treatment C

Since we have data about initial and final mental model similarity for participants of group C, we can determine and evaluate their mental model improvement. We can also measure the effect of these variables on Mental Model Similarity and Performance.

	Description
C-IMMS	Mental model similarity measured before simulation task
C–MMI	Mental model improvement by simulation task = MMS – IMMS

Table 3 – Specific Variables of Treatment C

4. Results

The 73 participants were distributed across the three treatments (treatment A – 24 treatment B – 24 treatment C – 25). Table 4 presents minimum, maximum and mean values, and standard deviations for the dependent variables for each treatment group. Table 5 shows the test of significance for difference in means between treatment groups.

The participants of group C - balanced scorecard interface and strategy map review - showed on average the best MMS (mean=0.443, sd=0.126, min=0.205, max=0.708) and the best Performance (mean=628, sd=409, min=-432, max=1089). As shown in table 5, the mean values of MMS and Performance for group C were significantly different from same values for groups A (mean dif=0.189, $p<0.001$) and B (mean dif=0.144, $p<0.001$).

On average, the participants of group B - balanced scorecard interface - showed a better MMS (mean=0.295, sd=0.077, min=0.093, max=0.429) than participants of group A - financial scorecard interface - (mean=0.250, sd=0.080, min=0.122, max=0.406). Table 5 shows that such difference was significant at $p<0.05$ (mean dif=0.045, p=0.043). Participants of group A (mean=329, sd=450, min=-715, max=854) and participants B (mean=310, sd=687, min=-1148, max=1189) showed similar mean value for Performance (mean dif=18, p=0.925).

Treatment	Description	Mental Model Similarity			Performance		
		Min/Max	Mean	Standard Deviation	Min/Max	Mean	Standard Deviation
A	Low LSC, Low LSM	0.122/ 0.406	0.250	0.080	-715/ 854	329	450
B	High LSC, Low LSM	0.093/ 0.429	0.295	0.077	-1148/ 1189	310	687
C	High LSC, High LSM	0.205/ 0.708	0.443	0.126	-432/ 1089	628	409
Cbs	Before simulation	0.128/ 0.442	0.253	0.089			

Table 4 – Means and standard deviations for Mental Model Similarity and Performance for each treatment group

Pair	Mental Model Similarity			Performance		
	Mean Difference	Standard Deviation	Significance p	Mean Difference	Standard Deviation	Significance p
A-B	-0.045**	0.102	0.043	18	939	0.925
B-C	-0.144***	0.153	0.000	-313**	632	0.023
A-C	-0.189***	0.139	0.000	-295**	592	0.023
A-Cbs	0.002	0.118	0.950			
B-Cbs	0.043*	0.121	0.093			
C-Cbs	0.190***	0.135	0.000			

*p<0.1; **p<0.05; ***p<0.001

Table 5 – Test of significance for difference in means between treatment groups

The mean value for Mental Model Similarity for treatment C before simulation (table 4), represents the participants' understanding about the simulated business system after they read the text case. Table 5 shows that the difference in means for MMS between C and Cbs was very significant (mean dif=0.190, p<0.001). We can see that the differences in means for MMS from participants A/B and participants C-before simulation were not very significant.

The correlation (Pearson) matrix for the regression analysis shows significant effects of the independent variables LSC and LSM on the Mental Model Similarity (table 6). There are significant effects of Mental Model Similarity on Performance. There are suggestive effects of Simulation Experience on Performance. LSC does not significantly correlate with Performance. There is not a significant interaction effect of Time and Age on Mental Model Similarity or Performance.

	MMS	Performance
Time	0.051	-0.012
Age	0.057	0.008
Simulation Experience	0.087	0.226*
LSC	0.448***	0.126
LSM	0.641***	0.272**
MMS		0.494***

*p<0.1; **p<0.05; ***p<0.001

Table 6 – Correlations (Pearson)

Table 7 shows the correlations (Pearson) for variables Initial Mental Model Similarity, Mental Model Improvement, MMS and Performance within group C. Unexpectedly, there does not seem to be a significant effect of Initial Mental Model Similarity on Mental Model Similarity or Performance. It suggests that IMMS, that represents the initial understanding about the simulated business system, does not significantly influences Performance. Thus, Performance is mostly driven by MMI, that represents the improvement of participant' understanding about the simulator.

	MMS	Performance
C - Initial Mental Model Similarity	0.246	-0.033
C - Mental Model Improvement	0.770***	0.633***

***p<0.001

Table 7 – Correlations (Pearson) for variables Initial Mental Model Similarity, Mental Model Improvement, MMS and Performance within group C

Table 8 shows the results of multi-regressing Mental Model Similarity and Performance on the independent variables. The regressions were run on standardized values for all variables to be able to directly compare the relative effect of each independent variable on the dependent variable.

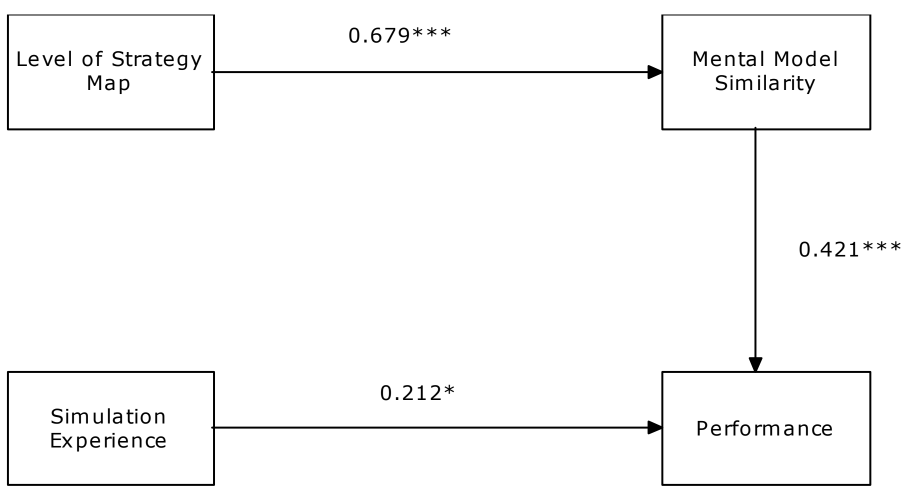
As shown in table 8, regressing Mental Model Similarity on the independent variables (R^2adjusted=0.450, $p<0.001$) showed a very significant effect for LSM ($\beta=0.615$, $p<0.001$), not very significant effect for LSC ($\beta=0.166$, $p<0.137$) and no significant effect for other variables. Regression on Performance (R^2adjusted =0.195, $p=0.004$) showed a significant positive effect for MMS ($\beta=0.550$, $p<0.001$), a suggestive effect for Simulation Experience (β=0.278, p=0.028) and no significant effect for other variables.

Independent Variables	Dependent Variables			
	Mental Model Similarity		Performance	
	Standardized Beta	Significance P	Standardized Beta	Significance P
Time	-0.025	0.811	0.004	0.973
Age	0.132	0.227	-0.123	0.357
Simulation Experience	-0.079	0.443	0.278**	0.028
LSC	0.166	0.137	-0.154	0.264
LSM	0.615***	0.000	0.072	0.656
MMS			0.540***	0.001
Adjusted R^2	0.450		0.195	

*p<0.1; **p<0.05; ***p<0.001

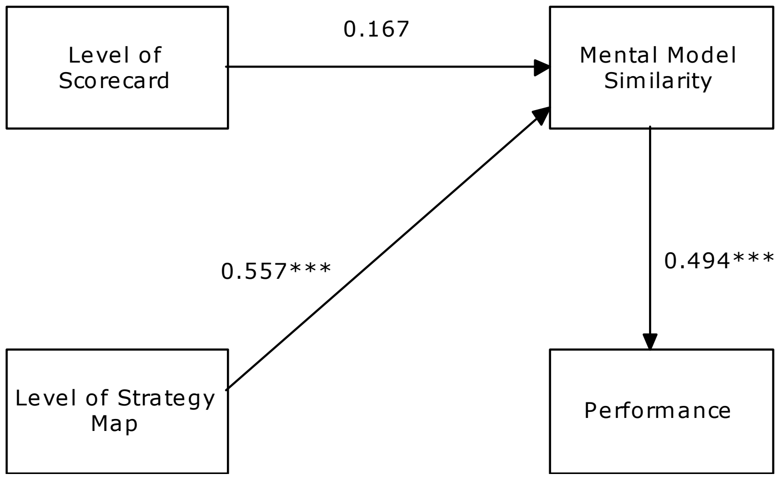
Table 8 - Regression results for all independent variables

We refined the regression model by performing a stepwise regression procedure in order to exclude the variables that do not seem to significantly explain the dependent variables and to keep the most explanatory variables (figure 12).



*p<0.1; ***p<0.001

Figure 12 – Regression model with explanatory variables remaining from a stepwise regression.



***p<0.001

Figure 13 – Regression for research model

As shown in figure 12, regressing Mental Model Similarity on the most explanatory independent variables (R^2adjusted=0.453, p<0.001) showed a very strong effect for LSM (β=0.679, p<0.001). LSC was excluded, as the effect for this variable was not significant. Regression on Performance (R^2adjusted =0.213 p<0.001) showed a very significant effect for MMS (β=0.421, p<0.001) and a suggestive effect for Simulation Experience (β=0.212, p<0.1).

Figure 13 shows the regression model by considering the main variables that were defined in the research model. Regression on Mental Model Similarity (R^2adjusted=0.415, p<0.001) showed not very significant effect for LSC (β=0.167, p=0.115) and a very significant effect for LSM (β=0.557, p<0.001). Regression on Performance (R^2adjusted =0.233, p<0.001) showed a very significant effect for MMS (β=0.494, p<0.001).

On average, the participants of group B - balanced scorecard interface - showed a better MMS than participants of group A - financial scorecard interface - (table 4), and such difference were significant (table 5). But the regression results did not point out a significant positive effect for LSC on Mental Model Similarity. Thus, the present research does not provide full support to Hypotheses H1 - the Level of Scorecard positively influences Mental Model Similarity.

These findings provide support for Hypotheses H2 - The Level of Strategy Map positively influences Mental Model Similarity and Hypotheses H3 - Mental Model Similarity positively influences Performance.

As shown in table 9, LSM significantly influences MMS. The regression analysis "Performance (1)" shows a significant effect of LSM on Performance (β=0.280, p<0.05). When MMS is added to the regression analysis "Performance (2)", MMS significantly influences Performance (β=0.565, p<0.001) and the influence of LSM on Performance decreases greatly and is not significant (β=-0.034, p=0.810). These results provide support for the mediation of Mental Model Similarity on the effect of the independent variable Level of Strategy Map on the dependent variable Performance (Hypotheses H4).

Independent Variables	Dependent Variables					
	Mental Model Similarity		Performance (1)		Performance (2)	
	Standardized Beta	Significance p	Standardized Beta	Significance p	Standardized Beta	Significance p
LSC	0.167	0.115	-0.016	0.905	-0.110	0.372
LSM	*0.557****	*0.000*	*0.280***	*0.039*	*-0.034*	*0.810*
MMS	-	-	-	-	*0.565****	*0.000*
Adjusted R^2	0.415		0.048		0.223	

*p<0.1; **p<0.05; ***p<0.001

Table 9 - Regression Analysis: Test for Mediation of MMS

Hypotheses	Description	Results
H1	The Level of Scorecard positively influences Mental Model Similarity	Not Full Supported
H2	The Level of Strategy Map positively influences Mental Model Similarity	Supported
H3	Mental Model Similarity positively influences Performance	Supported
H4	Mental Model Similarity mediates the effect of Level of Strategy Map, on Performance.	Supported

Table 10 – Summary of Hypotheses Testing

5. Discussion

The results confirmed three of the four hypotheses. Using strategy map in the process of strategy review and implementation, significantly improved the mental model similarity of participants, supporting Hypotheses H2. Thus, the strategy map process seems to produce a more effective double-loop learning.

We identically found that improved mental model similarity led to better performance, supporting Hypotheses H3. Therefore, the level of double-loop learning effectiveness (viewed as the improvement of mental models) seems to improve management performance.

The results also confirmed the Hypotheses H4 (mediation of Mental Model Similarity on the effect of Level of Strategy Map on Performance).

On average, the participants of group B - balanced scorecard interface - showed a better MMS than participants of group A - financial scorecard interface - (table 4), and such difference in means were significant (table 5). It suggested that LSC had a positive effect on MMS. But the regression results did not point out a significant positive effect for LSC on Mental Model Similarity. Thus, the present research does not provide full support to Hypotheses H1 - the Level of Scorecard positively influences Mental Model Similarity. This inconsistency of results might be due to a small sample size.

The lowest values for variables MMS and Performance were found in participants of group B - balanced scorecard interface. One can suggest that this is due to the stress between accessing a lot of information, much more than participants of group A with financial scorecard interface, and misunderstand the indicators structure and behaviour. This stress could have lead to desperation and to earlier giving up.

As we hypothesized, the results suggest that the process of strategy map review gave participants C a powerful tool that accelerated their learning about the simulated business system. However, we did not expect such a great impact of Level of Strategy Map on Mental Model Similarity. One possible explanation came from an informal debriefing with some participants of group C. It might be that as participants of group C accessed the initial strategy map just after finishing practice simulation, they tested their first assumptions more effectively and then they might have taken some advantage by starting definitive simulation with a better understanding about the simulator. A second explanation might be that participants with high LSM gave more attention to their mental models eliciting task (by reviewing the strategy map) than participants with low LSM (by answering the final questionnaire).

The differences in means for MMS from participants A/B and participants C-before simulation were not very significant (table 5). It suggests that participants from group A (using financial scorecard) and B (using balanced scorecard without strategy map) on average did not learn much about the simulated business system.

Interestingly, the results indicated that the total time participants spent on the task did not influence Mental Model Similarity or Performance.

As we expected, previous experience in business game simulators positively influenced participant performance.

6. Managerial Implications

This research provides some contributions to the managerial field by showing: (1) how to use the BSC approach in order to improve double-loop learning and performance; (2) to what extent managers improve strategic learning by using simple causal diagrams; (3)

how a better understanding of cause-and-effect relationships leads to a performance improvement and (4) how managers' mental models influence organizational performance.

As it happened in some previous research (for example Ittner et al., 2003; Braam and Nijssen, 2004; Strohhecker, 2004), this work did not find significant evidences that by using the BSC as a performance measurement system, managers learn more effectively about the business system and improve organization performance.

The results about the strong impact of the causal diagram review process (strategy map) on learning and performance, confirms that the feedback process for modeling and reviewing manager assumptions about cause-and-effect relationships leads to a better understanding of the business context and organization performance.

The two previous findings seem to indicate that the BSC usage only leads to improvement of organization performance if managers do understand the cause-and-effect relationships that link drivers and future financial performance. Our findings seem to confirm what Ittner and Larcker (2003) pointed out that many companies failed in using balanced scorecard because managers made little attempt to model and validate their understanding about the causal relationships between non-financial indicators and future financial performance.

As it was suggested by previous research (Ritchie-Dunham, 2002), we identically found that improved mental model similarity led to better performance. The results also indicate the mediation effect of Mental Model Similarity on the effect of the manner that BSC approach is used on performance.

In general terms, these findings reinforce the importance of the Mental Model construct to investigate how managers learn about business systems and its impact on management performance in dynamical decision-making processes. In particular, this research points out that to improve mental models managers should deal with very simple systems thinking approaches like causal diagrams to model and review their understanding about the business context.

7. Reference List

ARGYRIS, C. (1999). *On Organizational Learning*. Blackweel Publishing.

AKKERMANS, Henk and Kim van Oorschot, (2002). *Developing a Balanced Scorecard with System Dynamics.* Proceedings of the 20th International Conference of the System Dynamics Society.

BRAAM, G. and E. Nijssen, (2004). *Performance Effects of Using the Balanced Scorecard: a Note on the Dutch Experience*. Long Range Planning, 37, 335-349.

COPELAND, T, T. Koller and J. Murrin, (2000). *Valuation – Measuring and Management the Value of Companies*. John Wiley & Sons.

CRAIK, K., (1943). *The Nature of Explanation*. Cambridge Univ. Press.

DOYLE, J. and D. Ford, (1998). *Mental Models Concepts for System Dynamics Research*. System Dynamics Review, 14 (1), 3-29.

DOYLE, J and D. Ford, (1999). *Mental Models Concepts Revisited: Some Clarifications and a Reply to Lane*. System Dynamics Review, 15 (4), 411-415.

DOYLE, J., D. Ford, M. Radzicki, and S. Trees, (2001). *Mental Models of Dynamic Systems.* Encyclopedia of Life Support Systems. EOLSS Publishers, September. At http://www.wpi.edu/Academics/Depts/SSPS/Research/Papers/27.pdf.

FORRESTER, Jay W., (1961). *Industrial Dynamics*. Pegasus Communications.

ITTNER, C and D. Larcker, (1998). Innovations in performance measurement: Trends and research implications. *Journal of Management Accounting Research* (10): 205-238.

ITTNER, C and D. Larcker, (2003). *Coming Up Short on Nonfinancial Performance Measurement*. Harvard Business Review, Nov , pp 88-95.

ITTNER, C., D. Larcker and T. Randall, (2003). *Performance Implications of Strategic Performance Measurement in Financial Services Firms.* Accounting, Organizations and Society, 28, pp 715-741.

JOHNSON-LAIRD, P. (1990). *Mental Models: Towards a Cognitive Science of Language, Inference and Consciousness*. Harvard Univ. Press.

KAPLAN, R. S, and D. P. Norton, (1992). *The Balanced Scorecard – Measures that Drive Performance*. Harvard Business Review, Jan-Feb, pp 71-79.

KAPLAN, R. S, and D. P. Norton, (1996a). *The Balanced Scorecard.* Boston, MA, Harvard Business School Press.

KAPLAN, R. S, and D. P. Norton, (1996b). *Linking the Balanced Scorecard to Strategy.* Californian Management Review, Fall, Vol 39, 1, pp 53-79.

KAPLAN, R. S, and D. P. Norton, (2000). *Having Trouble with Your Strategy ? Then Map It*. Harvard Business Review, Sep-Oct, pp 167-176.

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

KAPLAN, R. S, and D. P. Norton, (2001b). *Transforming the Balanced Scorecard from Performance Measurement to Strategic Management: Part II.* Accounting Horizons, Vol 15, nº 2, June, pp 147-160.

KIERAS, D. E, and S. Bovair, (1984). *The Role of Mental Model in Learning to Operate a Device*. Cognitive Science, 8, pp 255-273.

LINGLE, J. and W. Schiemann, (1996). *From Balanced Scorecard to Strategic Gauges: Is Measurement Worth It ?*. Management Review, 85(3), pp. 56-61.

NORREKLIT, H., (2000). *The Balance of the Balanced Scorecard: A Critical Analysis of Some of Its Assumptions.* Management Accounting Research, Vol 11, 1, Mar.

NORREKLIT, H., (2003). *The balanced scorecard: What is the score? A rhetorical analysis of the balanced scorecard.* Accounting, Organizations and Society 28(6): 591-619.

OLVE, N., J. Roy and M. Wetter, (2000). *Performance Drivers: A Practical Guide to Using the Balanced Scorecard.* Chichester, John Wiley & Sons.

POWERSIM. Powersim Software AS. http://www.powersim.com/

RITCHIE-DUNHAM, J., (2001). *Informing Mental Models for Strategic Decision Making with ERPs and the Balanced Scorecard: A Simulation – Based Experiment.* Proceedings of the 19th International Conference of the System Dynamics Society, Atlanta, Georgia, USA.

RITCHIE-DUNHAM, J., (2002). *Balanced Scorecards, Mental Models, and Organizational Performance: A Simulation Experiment.* Unpublished PhD Dissertation, University of Texas at Austin, Austin, USA.

ROWE, A.L. and N.J. Cooke, (1995). *Measuring Mental Models: Choosing the Right Tools for the Job.* Human Resource Development Quarterly 6 (3), pp 243-255.

RIGBY, D, (2001). *Management Tools and Techniques: A Survey.* Californian Management Review, Winter, Vol 43, 2, pp 139-160.

SCHVANEVELDT, R. (1990). *Pathfinder Associative Networks: Studies in Knowledge Organization*. Norwood, NJ: Ablex.

SENGE, Peter M, (1990). *The Fifth Discipline*. New York, Doubleday.

SIMON, H. (1997). *Administrative Behaviour.* 4ª ed. New York Free Press.

SPECKBACHER, G., J. Bischof and T. Pfeiffer, (2003). *A Descriptive Analysis on the Implementation of Balanced Scorecards in German-speaking Countries.* Management Accounting Research 14, pp 361-387.

STERMAN, J., (2000). *Business Dynamics: System Thinking and Modeling for a Complex World.* New York, Irwin Mcgraw-Hill.

STIVERS, B. P., T. J. Covin, N. G. Hall and S. W. Smalt, (1998). *How nonfinancial performance measures are used*. Management Accounting (Fev), 44, 46-49.

STROHHECKER, J. (2004). *Simulation Based Experiments for Testing the Balanced Scorecard's Built-in Performance Improvement Theory*. Proceedings of the 22th International Conference of the System Dynamics Society, Oxford, England.

WARREN, Kim, (2002). *Competitive Strategy Dynamics*. Chichester, John Wiley & Sons.

WYMAN, B. and J. Randel. (1998). *The Relation of Knowledge Organization to Performance of a Complex Cognitive Task.* Applied Cognitive Psychology, 12, pp 251-264.