Analyzing Training Programs from a KM perspective: A System Dynamics model

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Abstract: Service operations depend intensively on human resources because of their interaction with customers and suppliers and thus, feel the need to train their staff in order to ensure organizational performance over time. Knowledge management may be a framework for training programs since it addresses knowledge conversion from explicit and tacit knowledge. This paper proposes that dynamic simulation may be used as a tool to model and analyze the knowledge management aspects associated with training programs within an organization. Three scenarios are considered, relying on the number of trainings per month. The model was built using data from a customer support service of a software-house in Brazil and subsequently, tested using real data. By simulating different scenarios, best decision making guidelines are provided to reduce uncertainty and customer loss. It concludes that i) training programs can be analyzed from a knowledge management perspective; ii) the knowledge conversion process between tacit and explicit affects the effectiveness of training programs and thus, the organization´s performance; and iii) system dynamics modeling helps service managers to make decisions related to training programs, by providing micro-world simulations in order to test and to analyze different strategies.

Keywords: Knowledge Management, Training and Development Programs, System Dynamics, Service Operations.

Introduction

Service operations depend intensively on their human resource, because of the interactions with both customers and suppliers in which value co-production is an inherent property (Fitzsimmons and Fitzsimmons 2007; Maglio et al. 2009).

As Cook et al. (2002) points out only with the understanding of the underlying principles of human interactions, service operations can be approached with the same depth and rigor than on manufacturing ones.

Humans are the producers and users of knowledge, which is ultimately the primary resource in service operations, opening different challenges to managers and academics than those of manufacturing.

One of the most important aspects that need to be considered is how to keep the organization's knowledge base, in other words, how to ensure that technical knowledge distributed among the staff is not getting lost rather than creating new knowledge.

This is possible through the constant review of staff training and development, in order to improve knowledge, skills and attitudes that could enhance organizational effectiveness (Buckley and Caple 2008; Aguinis and Kraiger 2009). In the remainder of this work, we use the term "training" to refer to both training and development efforts.

Pertaining to staff training, knowledge management has proven to be an effective strategy since it addresses knowledge identification, acquisition, storage and transfer in organizations (Davenport and Prusak 2000).

In service operations, training programs are highly complex, since the labor and knowledge intensity of services; accordingly, service intangibility, simultaneity and non-stockability, hinder the learning process by affecting on the tacit-explicit knowledge cycle.

Despite this increase, there is still little confidence regarding the scientific rigor of these programs since poor empirical support.

According to Chen and Klimoski (2007) the lack of clear scientific rigor can hinder knowledge creation and accumulation, thus, leading to inefficient use of human and financial resources and loss of competitive advantages, even harming both employees and the organizations that employ them.

Not only less than 5% of all training programs are assessed in terms of financial benefits for the organization as Aguinis and Kraiger (2009) point out, but the lack of scientific rigor can hinder also, the effectiveness of those evaluations.

This paper proposes the use of dynamic simulation, specifically system dynamics, as a tool to model and to analyze the knowledge management aspects associated with staff training within an organization.

Simulation, as discussed in literature, is the process of building a model of a real system and to conduct dynamic experiments with it (Pidd 1998; Robinson et al. 2004; Giaglis et al. 2005).

In this sense, the customer service of a software-house in Florianopolis, Brazil was modeled. The customer service process in software development industry has been described as knowledge and labor-intensive (Uriona Maldonado 2008).

Through the use of a system dynamics model built in iThink[1], the contribution of this work lies on shedding light over the intangible effects of tacit and explicit knowledge that support the effectiveness of training programs over organizational performance.

Service Operations Systems

Organization main goals are basically to "get and keep customers" and to "make a profit" (Berry, Hill, and Klompmaker 1995). Both goals depend on the Production

[1] iThink is a registered trademark of Isee Systems Inc. (www.iseesystems.com).

System, which is responsible for producing goods and services in the organizations, therefore Operations Strategy is vital for gaining competitive advantage and for delivering quality services to customers (Chase, Aquilano, and Jacobs 2004).

For Chase et al. (2004) and Gianesi & Corrêa (1994) Operations Strategy refers to plans and politics formulation, seeking the best use of operative resources, for supporting the Firm's strategy, by the production of goods and services that satisfies costumers' needs (Slack 2005).

Operations Strategy implies decisions related to production processes design and supporting infrastructure for those processes, namely: service project, process-technology, facilities, capacity-demand, workforce, quality, customer management, performance measurement, operations control and improvement systems, among others (Chase, Aquilano, and Jacobs 2004).

According to Roth et al. (1994), the competitiveness comparison basis have changed since new types of non-tangible products are becoming more common, pushing organizations to achieve a state called "customer-readiness", influenced by new value-added sources like organizational knowledge.

Terms like the "knowledge factory", the "knowledge-creating company" and the "knowledge worker" refer to a new competitive priority in organizations, which is to create organizational knowledge through learning in parallel with service production (Roth et al. 1994; Nonaka 1994; Hammer, Leonard, and Davenport 2004; Drucker 1999).

Training programs and Knowledge Management

Due to the constant increasing demands of the markets as well as the levels of competitiveness, employees are forced to continuously update their knowledge, skills and attitudes, and organizations to invest in training their staff in order to ensure improved organizational performance (Chen and Klimoski 2007).

For Goldstein and Ford (2002) training programs are "the systematic approach to affecting individuals' knowledge, skills, and attitudes in order to improve individual, team, and organizational effectiveness".

As the amount of published literature referring on training programs grows, several fields have researched this subject, from human resource management through instructional design, human resource development, human factors and knowledge management, although they borrow heavily from theories developed in more basic sciences, such as cognitive psychology (Aguinis and Kraiger 2009; Chen and Klimoski 2007); this paper will focus on the knowledge management perspective.

From an organizational knowledge creation approach, knowledge management addresses knowledge identification, acquisition, storage and transfer in organizations (Davenport and Prusak 2000; Dalkir 2005).

For Davenport and Prusak (2000) KM is the "collection of process that aims to govern the creation, dissemination and use of (organizational) knowledge, in order to reach organizational objectives". Schreiber et. al. (2002) defines KM as "a framework and tool set for improving the organizational knowledge infrastructure, aimed at getting the right knowledge to the right people in the right form at the right time”.

As Aguinis and Kraiger (2009) point out, training programs result in subtle improved performance, sometimes hard to measure. Most of the performance comes from “informal learning” as Barber (2004) noted, were the tacit knowledge has a major influence.

Tacit knowledge is difficult to articulate and resides “within the heads of knowers”; the other type of knowledge is explicit knowledge, and represents knowledge that has been captured in some kind of media, like text, audio or images (Dalkir 2005).

From the KM perspective, around and 80% of our knowledge is in tacit form, which means that only 20% is knowledge that can be codified in order to share it with other individuals. This means that training programs can be effective only when explicit knowledge is converted into tacit knowledge, when employees develop an “intuitive feel” (Barber 2004).

As Tharenou et al. (2007) suggests, there are few empirical studies showing the effects of training programs over organizational performance. However, there are some studies that will be described as followed.

Aragon-Sanchez et al. (2003) surveyed 457 small and medium-sized companies in the United Kingdom, the Netherlands, Portugal, Finland, and Spain. They established two macro-indicators for organizational performance: i) effectiveness (i.e., employee involvement, human resource indicators, and quality), and ii) profitability (i.e., sales volume, benefits before interest and taxes). Their results indicated that on-the-job training as well as in-house training were positively related to both indicators.

Ubeda Garcia (2005) studied 78 spanish companies with more than 100 employees. This study related the organization´s training policies with four organizational results: employee satisfaction, customer satisfaction, owner/shareholder satisfaction and workforce productivity. The results suggested that policies oriented toward human capital development were directly related to all four results.

Guerrero and Barraud-Didier (2004) surveyed more than 1500 human resource directors of large firms in France and compared them with the firm´s financial information one year later. The results suggested that 4.6% of the variance in financial performance was explained by training practices.

Finally, Mabey and Ramirez (2005) surveyed 179 companies in the United Kingdom, Denmark, France, Germany, Norway and Spain. Two main indicators were analyzed: operating revenue per employee and cost of employees as a percentage of operating revenue. Their results suggested that firms with management development programs were more likely to have a positive relationship between management development and financial performance.

The evaluation of training programs and its effects over organizational performance is harder in service operations due to their intangibility and labor and knowledge intensity.

These studies were conducted using a survey approach; this paper proposes to use an alternative approach for analyzing the impacts of training programs on performance, through simulation experiments.

Experimental Design

Research Design

The methodological steps of this paper followed Forrester's and Sterman's recommendations for system dynamics applications: problem identification, model formulation, simulation and validation, and policy analysis (Forrester 1994; Sterman 2000).

Problem identification was done by using surveys and questionnaires. The company´s goal was to identify the number of monthly trainings that would bring the best positive outcomes.

Among the company, eleven stakeholders were interviewed in order to comprehend the subtle dynamics of the company. The author of this work was in a management position on this company for a period of 20 months, his experience also enriched data collection from this step.

Model formulation was done using iThink software, as well as simulation and validation.

And policy analysis was supported by the analysis of scenarios. Three scenarios were considered, relying on the number of trainings per month.

Simulation Method Choice

The modeling and simulation method selected in this work was System Dynamics. Created by J.W. Forrester in late 1950s, System Dynamics allows complex system simulation through stock and flow metaphors (Forrester 1989).

The main principles of System Dynamics are that behavior of a complex dynamic system is the result of its structure (causal relationships, feedback loops and time delays) (Sterman 2000).

Often, the complexity of a system is simply related to the amount or components of a system. However, it is dynamic complexity – the counterintuitive behavior of complex systems that arises from the interactions of the agents over time (Forrester 1971) – the unanticipated events or side effects that policy makers face when the system behaves in a hardly predictable way.

The major effect of dynamic complexity over system behavior is what Sterman (2000) defines as "policy resistance" - the tendency of a system to defeat human-based interventions by the system´s response to the intervention itself (Sterman 2006) - in other words, the system´s auto-regulation mechanism that seeks to re-establish the "entropic equilibrium" that was present on the system before any intervention was made.

For Sterman (2006), it is our mental model that narrows our vision of the system, thus blocking our awareness that there are other variables that provoke certain system behaviors that would, at first glance, appear to be unanticipated. This narrowness hinders our ability to make better decisions in order to impose certain mechanisms that could change system behavior for our benefit.

Through SD modeling and simulation techniques, it is possible to develop new understandings and mental models related to the dynamic complexity surrounding the system in study. It is our assertion that dynamic complexity is a determinant factor on service systems especially when intangible variables like knowledge and learning are in study.

Model-related aspects

The data was collected from a software-house in Florianopolis, Brazil, whose products are targeted for the accounting market. The company is structured in two main areas, Management, which is composed by Marketing and Financial Areas, and Technical, composed by R&D, Mediation and Technical Support Areas.

The focus of this paper will be the company's customer service, due to its importance for service delivery, and the complexity of the activities made by their Technical staff.

The model was built considering Customer, Workforce, Financial, Service Production and Knowledge Management variables.

The Customer Management Model (CMM) was considered after Berry et al. (1995) recommendations about the main goals of an organization "to get and to keep costumers".

The Workforce Management Model (WMM) serves to simulate the impacts of staff on service production.

Berry et al. (1995) also sustains that another main goal of any organization is to "make a profit", thus a Financial Management Model (FMM) was also built.

In order to analyze the dynamics of the model, a Service Operations Model (SOM) was included.

And finally, a Knowledge Management Model (KMM), including tacit and explicit knowledge components that will simulate the effects of training staff over the service system.

Model Formulation

The complete System Dynamics Model is presented in Fig. 1, including the sub-models: CMM, WMM, FMM, SOM and KMM. In the next point, each one of them will be detailed and explained.

The model will be evaluated in three different scenarios related to Workforce Training investment policy: **Scenario 1** will consist of a single monthly training; **Scenario 2** will consist of 5 monthly trainings; **Scenario 3** will consist of 10 monthly trainings; and finally, **Scenario 4** will consist of 15 monthly trainings.

The output variables selected for comparison purposes will be: Customers, Mean Monthly Income, Mean Monthly Expenses, Accumulated Balance, Explicit Knowledge stock and Tacit Knowledge stock, those last two being non-dimensional variables. The period for simulation was stated in 100 months.

In the SO Model, service demand depends on the comparison between the competitors Lead Time and the own Lead Time. Service delivery depends on the quantity of workforce and on its quality, through productivity.

In the CM Model, the input flow depends on a word-of-mouth multiplier and on the satisfaction perceived on actual customers. In this model, satisfaction only depends on the rate between new services inflow and service delivery outflow.

In the Workforce Model, the structure is as follows, the inflow of new employees depends on the firing and additional hiring policies, the experienced employees depends on the quantity of new employees and on the time for “gaining” experience through training, the outflow depends on a rate of hiring employees each month. Fixed costs are dependable of salaries and of number of trainings developed monthly.

In the FM Model, both income and expenses are calculated relying on the quantity of services delivered, considering both variable and fixed costs.

In the KM Model, the explicit and tacit knowledge are modeled, considering the “knowledge creation and transfer” to workforce in terms of monthly trainings. It also considers the loss of “knowledge converted” caused by firing policies and the 80/20 knowledge rule explained by Dalkir (2005). This rule suggests that 80% of knowledge is tacit and only 20% explicit. For simulation purposes, the model starts with a pre-defined amount of tacit and explicit knowledge. When analyzing tacit and explicit knowledge variables, the model will simulate increases on both knowledge stocks over the initial pre-defined amount.

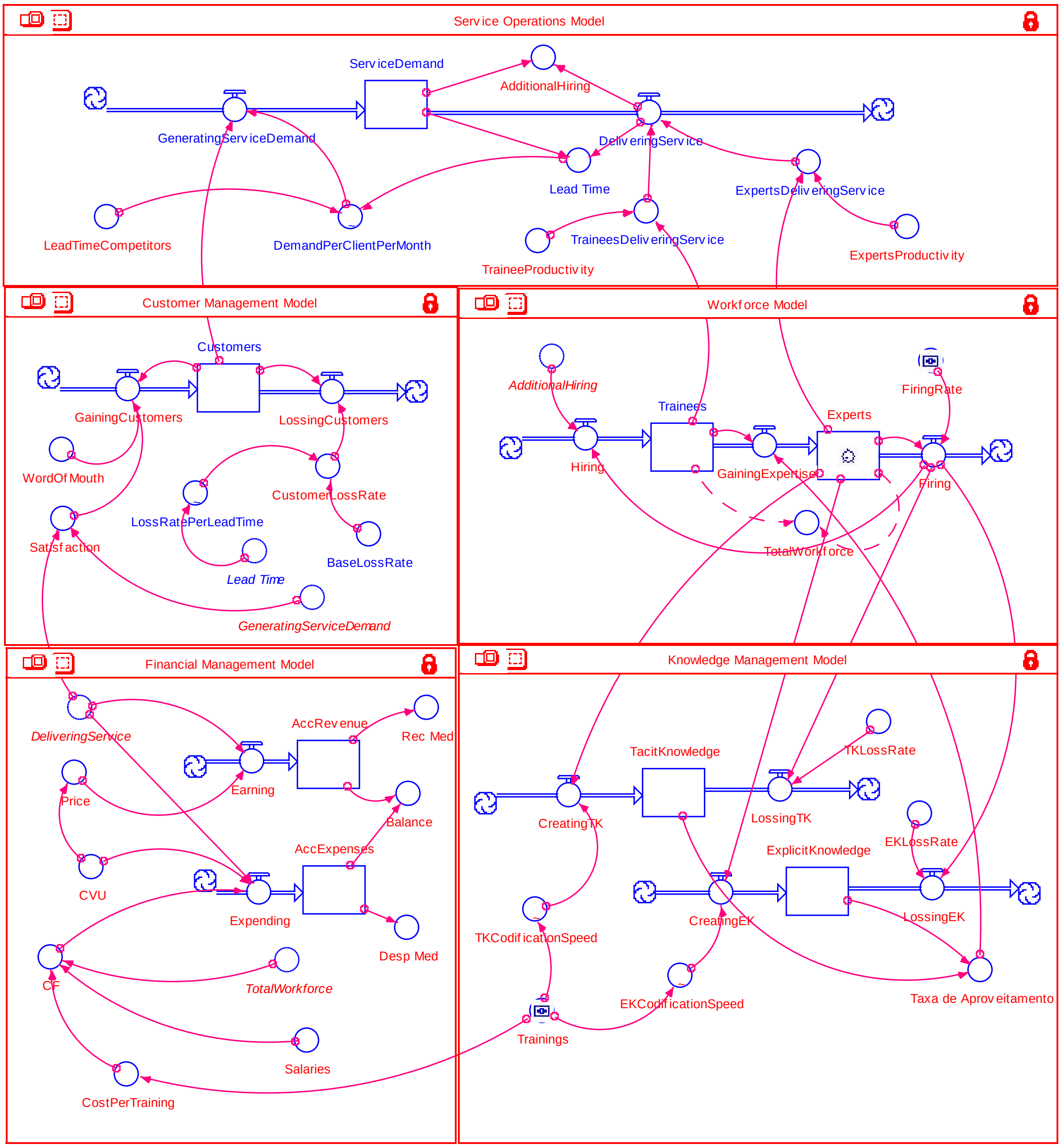

Figure 1. SD Model of the Service System

Simulation Results

Scenario 1 – One monthly training (1MT)

This scenario presents 1 (one) monthly training, considered to be low in training investment; the results obtained are presented in Figure 2. When having a low investment in training programs, the operational expenses are covered by incomes until the 67th month. The company gains customers until the 67th month where it starts to losing customers. Neither explicit nor tacit knowledge are created.

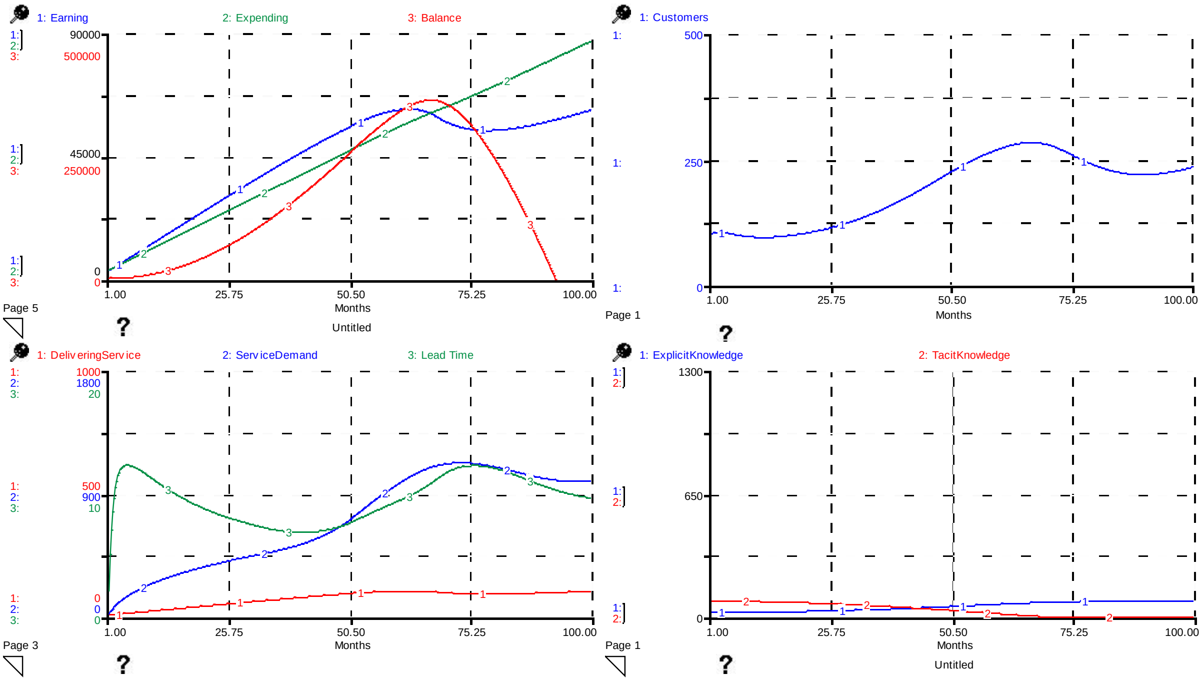

Figure 2 – Results with one monthly training

Scenario 2 – Five monthly trainings (5MT)

This scenario presents five (5) monthly trainings, considered to be high in training investment, the results obtained are presented in Figure 3. Financial results become positive with this scenario. There is a moderate increase in customers and also a moderate creation of explicit and tacit knowledge.

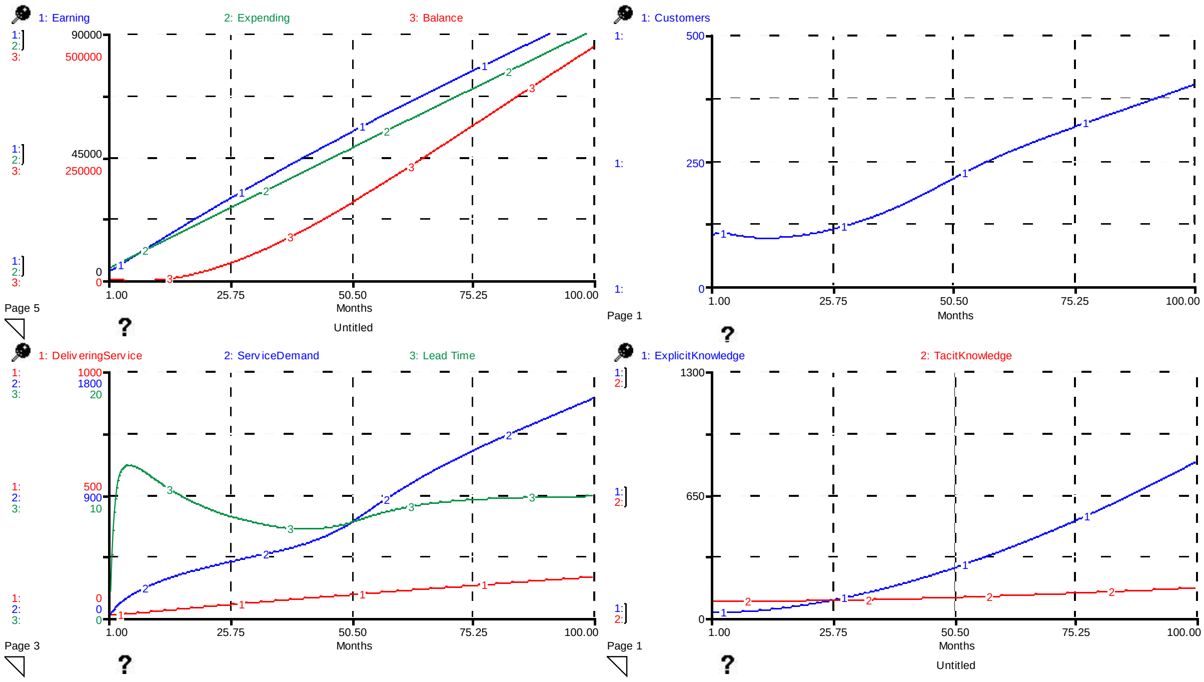

Figure 3 – Results with 5 monthly trainings

Scenario 3 – Ten monthly trainings (10MT)

This scenario presents ten (10) monthly trainings, considered to be high in training investment; the results are presented in Figure 4. With ten monthly trainings the service system also presents positive financial outcomes, however, for the first 25 months with negative results. Customers' increase is also observed as well a strong increase in explicit and tacit knowledge.

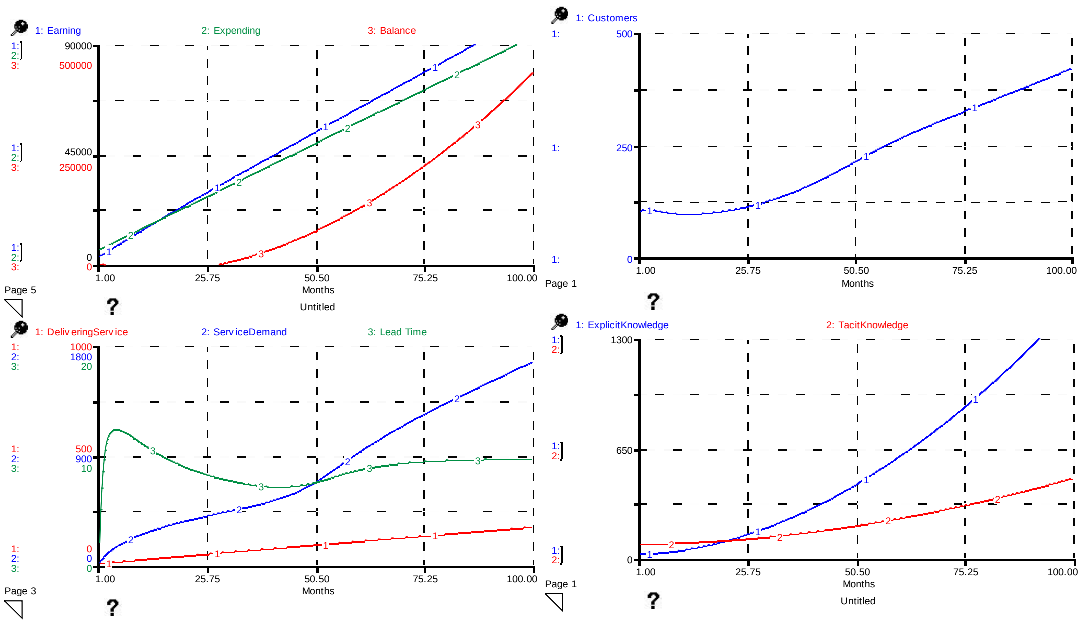

Figure 4 –Results with 10 monthly trainings

Scenario 4 – Fifteen monthly trainings (15MT)

This scenario presents fifteen (15) monthly trainings, considered to be strong training investment, the results of the simulation experiment presented in Figure 5. As same as the financial behavior of the last scenario, this fourth scenario presents initially financial losses a then a recovery starting in the 26th month. Customers increases moderately and explicit and tacit knowledge present strong increases.

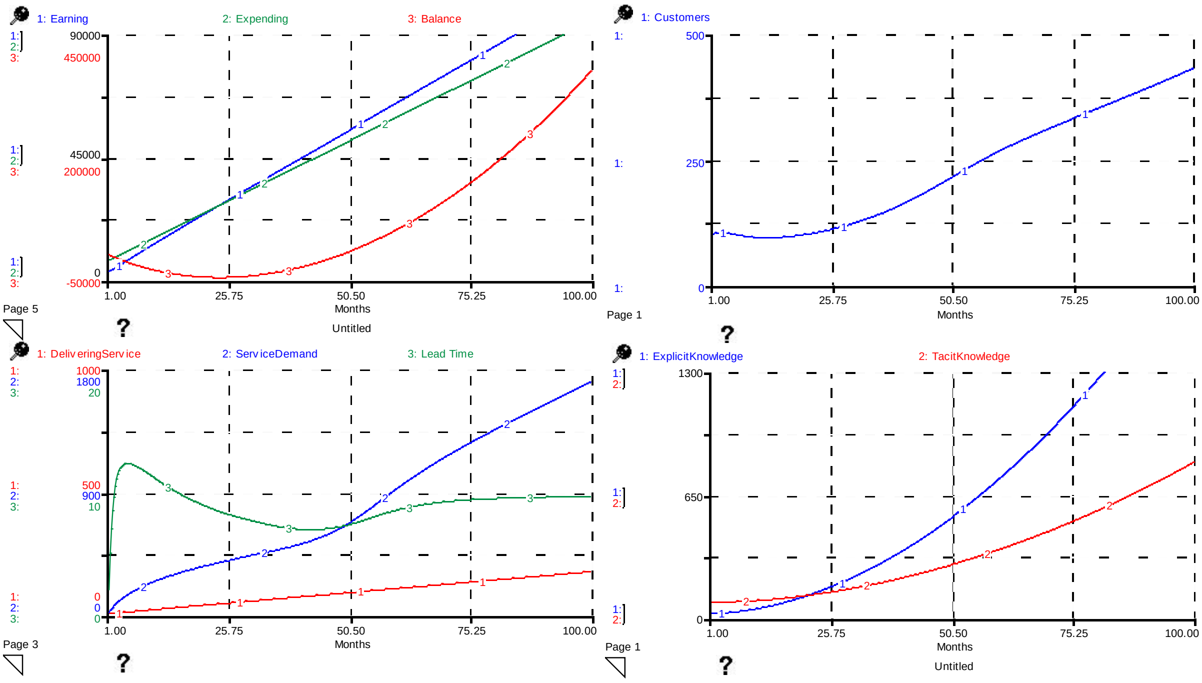

Figure 5 – Results with 15 monthly trainings

The summary of the results are presented in Table 1:

Table 1. Summary of the simulation results

Item (*)	Units	1 MT	5 MT	10 MT	15 MT
Customers	Customers	234	401	421	432
Monthly income	R$	43.657	52.018	53.231	54.207
Monthly expense	R$	45.416	47.300	48.886	50.453
Acc. Balance	R$	-175.879	471.730	434.435	375.420
Acc. Explicit K.	-	81	818	1.509	1.914
Acc. Tacit K.	-	0	153	470	821

(*) All values considered at the 100th month of simulation

Table 2 shows the comparisons of the results relative to Scenario 1 (1MT).

Table 2. Simulation results relative to Scenario 1 (MT)

Item (*)	1 MT	5 MT	10 MT	15 MT
Customers	1	1.71	1.80	1.85
Monthly income	1	1.19	1.22	1.24
Monthly expense	1	1.04	1.08	1.11
Acc. Balance	1	4.68	4.47	4.13
Acc. Explicit K.	1	10.10	18.63	23.63
Acc. Tacit K.	1	153.00	470.00	821.00

(*) All values considered at the 100th month of simulation

For customers, for each percent point in Scenario 1, all other scenarios presented increases, for 5MT an increase of 1.71, for 10MT an increase of 1.80 and for 15MT an increase for 1.85.

For monthly income, at the end of the 100th month, the increases were 1.19, 1.22 and 1.24 respectively for 5MT, 10MT and 15MT.

Similarly, for monthly expenses, the relative values were 1.04, 1.08 and 1.11 for five, ten and fifteen monthly trainings respectively.

In relation to the Balance, increase values were higher, 4.68 for 5MT, 4.47 for 10MT, and 4.13 for 15MT. We highlight that the greatest value in this variable was in Scenario 2 (5MT). Meaning the profit for scenario 2 was the highest in relation to other scenarios.

For explicit knowledge accumulation (EKA), 5MT presented approximately 10 times more EKA than 1MT, 18 times more in 10MT and 23 times more for 15MT.

Finally, tacit knowledge accumulation (TKA) for Scenarios 2, 3 and 4 were strongly highest than the value of Scenario 1.

Discussion and Conclusions

Results shown in Section 5 corroborate training and development theory when simulation results presents better performance after training programs have been developed.

For base-case scenario 1 (1MT), major variables present a similar behavior than the one found on real data from the company.

It is noted that with a single monthly training, the accumulation of new tacit knowledge is not possible or at least it is not used for improving performance, meaning that pre-defined amounts of tacit and explicit knowledge remain approximately constant.

Also for Scenario 1 (1MT) the difference between income and expenses produces a negative balance after the 100th month simulation. This may be explained by the inefficacy to improve performance in order to deliver services and in order to gain new customers. At the end of the simulation, poor training investments produce a negative overall outcome for the company.

For all other scenarios, 2, 3 and 4, financial results as well as intangible results (tacit and explicit knowledge) present positive outcomes, suggesting a direct relationship with the training programs variable.

In a qualitative analysis of results, it could be difficult to manage more than 10 monthly trainings for the technical staff without prejudicing operational activities. Even if results may appear originally appealing, other aspects like time for trainings must be considered.

Accordingly, we conclude that an adequate training program for the company should include between 5 and 10 monthly trainings, based on the results of the simulations.

In a broader sense, simulation models like the one presented in this paper help managers and specially service operations managers to make more informed decisions, by gaining a flight-simulation capability to test different policies.

The model replicated some outcomes presented in real business operations, such as hiring and firing policies and its effects on organizational knowledge and the customer gaining-losing dynamic. The model also captured the essence of the knowledge management dynamics, related to investments in training as a positive reinforcing loop aimed at obtaining higher service quality.

Considering this, it is reasonable to conclude that System Dynamics methodology, tools and techniques enhances decision making in service operations and especially when intangible variables are at study.

Though, this paper culminates in the recommendation of using simulation techniques for service operations systems, it calls for future extension of this research into the specific details of knowledge conversion, i.e. the SECI model of Nonaka (1994), into proximal trainee- and program-levels (e.g., trainers' support and instructional methods), as well as contextual elements like work-related climate and supervisor support that could influence on the knowledge conversion/creation process.

References

Aguinis, H., and K. Kraiger. 2009. Benefits of training and development for individuals and teams, organizations, and society. *Annual Review of Psychology* 60:451-474.

Aragón-Sánchez, Antonio, Isabel Barba-Aragón, and Raquel Sanz-Valle. 2003. Effects of training on business results. *International Journal of Human Resource Management* 14 (6):956-980.

Barber, J. 2004. Skill upgrading within informal training: lessons from the Indian auto mechanic. *Int. J. Train. Dev.* 8:128-139.

Berry, W., T. Hill, and J.E. Klompmaker. 1995. Costumer-driven Manufacturing. *International Journal of Operations and Production Management* 15 (3):4-15.

Buckley, G., and J. Caple. 2008. *The theory and practice of training*. 5th ed. London: Kogan Page.

Chase, Richard, N. Aquilano, and R. Jacobs. 2004. *Administración de Producción y Operaciones*. 10th ed. Mexico: McGraw Hill.

Chen, G., and R.J. Klimoski. 2007. Training and development of human resources at work: Is the state of our science strong? *Human Resource Management Review* 17 (2):180-190.

Cook, L. S., D. E. Bowenb, R. B. Chase, S. Dasuc, D.M. Stewart, and D.A. Tansik. 2002. Human issues in service design. *Journal of Operations Management* 20 (2):159-174.

Dalkir, K. 2005. *Knowledge Management in theory and practice*. Burlington: Elsevier.

Davenport, Thomas H., and Laurence Prusak. 2000. *Working Knowledge: how organizations manage what they know*. 2nd ed. USA: Harvard Business Press.

Drucker, P. 1999. *La sociedad post-capitalista*: Ed. Sudamericana.

Fitzsimmons, J., and M. Fitzsimmons. 2007. *Service Management: Operations, Strategy, Information Technology*. 6th ed. New York: McGraw Hill - Irwin.

Forrester, Jay W. 1971. Counterintuitive behavior of social systems. *Technology Review* 73:53-68.

Forrester, Jay W. 1989. The Beginning of System Dynamics. System Dynamics Group, Sloan School, Massachusetts Institute of Technology.

Forrester, Jay W. 1994. System Dynamics, Systems Thinking, and Soft OR. *System Dynamics Review* 10 (2/3):245-256.

Giaglis, George M., Vlatka Hlupic, Gert-Jan de Vreede, and Alexander Verbraeck. 2005. Synchronous design of business processes and information systems using dynamic process modelling. *Business Process Management Journal* 11 (5):488-500.

Gianesi, I.G.N., and H.L. Correa. 1994. *Administração estratégica de serviços : operações para a satisfação do cliente*. Sao Paulo: Atlas.

Goldstein, I.L., and J.K. Ford. 2002. *Training in Organizations*. 4th ed. Belmont, CA: Wadsworth.

Guerrero, S., and V. Barraud-Didier. 2004. High-involvement practices and performance of French firms. *Int. J. Hum. Resour. Manag* 15:1408-1423.

Hammer, M., D. Leonard, and Thomas Davenport. 2004. Why don't we know more about knowledge? . *MIT Sloan Management Review* 4 (45):14-18.

Mabey, C., and M. Ramirez. 2005. Does management development improve organizational productivity? A six country analysis of European firms. *Int. J. Hum. Resour. Manag* 16:1067-1082.

Maglio, Paul P., Stephen L. Vargo, Nathan Caswell, and Jim Spohrer. 2009. The service system is the basic abstraction of service science. *Information Systems and E-business management* 7 (4):395-406.

Nonaka, Ikujiro. 1994. A Dynamic Theory of Organizational Knowledge Creation. *Organizational Science* 5:14-37.

Pidd, Michael. 1998. *Computer Simulation in Management Science*. 4th ed. New York: John Wiley & Sons, Inc.

Robinson, Stewart, Richard E. Nance, Ray J. Paul, Michael Pidd, and Simon J.E. Taylor. 2004. Simulation model reuse: definitions, benefits and obstacles. *Simulation Modelling Practice and Theory* 12 (7-8):479-494.

Roth, Aleda V., Ann S. Marucheck, Alex Kemp, and Dong Trimble. 1994. The Knowledge Factory for accelerated learning practices. *Strategy & Leadership* 22 (3):26-46.

Schreiber, Guus, Hans Akkermans, Anjo Anjewierden, Robert de Hoog, Nigel Shadbolt, Walter Van de Velde, and Bob Wielinga. 2002. *Knowledge Engineering and Management: The CommonKADS Methodology*. Cambrigde: MIT Press.

Slack, Nigel. 2005. Operations Strategy, will it ever realize its potential? . *Gestão e Produção* 12 (3):323-332.

Sterman, John D. 2000. *Business Dynamics. Systems Thinking and Modeling for a complex world.* Boston: Mc Graw Hill Higher Education.

Sterman, John D. 2006. Learning from evidence in a complex world. *American Journal of Public Health* 96 (3):505-514.

Tharenou, Phyllis, Alan M. Saks, and Celia Moore. 2007. A review and critique of research on training and organizational-level outcomes. *Human Resource Management Review* 17 (3):251-273.

Ubeda-Garcia, M. 2005. Training and business performance: the Spanish case. *Int. J. Hum. Resour. Manag* 16:1691-1710.

Uriona Maldonado, M. 2008. Análise do Impacto das Políticas de Criação e Transferência de Conhecimento em Processos Intensivos em Conhecimento: Um modelo de Dinâmica de Sistemas. Dissertação de Mestrado, Programa de Pós-Graduação em Engenharia e Gestão do Conhecimento., Universidade Federal de Santa Catarina, Florianópolis.