Promoting Knowledge Management in Service System Design: A System Dynamics Approach

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Abstract: This paper shows the application of system dynamics on service system design, emphasizing the simulation of the knowledge management effects over the system’s behavior. It is argued that knowledge management must be considered on the system’s design phase, and that via simulation techniques the designer is able to evaluate various aspects of the system’s behavior, including the knowledge management effects, for each design alternative. These ideas are demonstrated by the simulation of a software-house’s technical support service.

Keywords: Service System Design, Knowledge Management, System Dynamics

Resumen: Este trabajo presenta la aplicación de Dinámica de Sistemas en el diseño de sistemas de servicios, enfatizando la simulación de los efectos de gestión del conocimiento en el comportamiento del sistema. Se argumenta que la gestión del conocimiento debe ser considerada en la fase de diseño del sistema de servicios y que a través de técnicas de simulación, el diseñador es capaz de evaluar varios aspectos relacionados con el comportamiento del sistema, incluyendo los efectos de la gestión del conocimiento en cada alternativa de diseño. Estas ideas son comprobadas a través de la simulación del un servicio de soporte técnico de una empresa de software.

Palabras clave: Diseño de sistemas de servicios, gestión del conocimiento, dinámica de sistemas.

Introduction

Intangibility, simultaneity and non-stockability clearly differentiate service from manufacturing operations (Gianesi & Correa, 1994). It has been suggested that service operations depends intensively on the human capital involved. Usually, service systems are based on a large number of interactions with both consumers and suppliers in which value co-production is an inherent property (Tung & Yuan, 2007). According to Maglio et al. (2006), “service systems are value-creation networks composed of people, technology, and organizations”.

Cook et al. (2002) suggest that only with the understanding of the underlying principles of human interactions, service design can be approached with the same depth and rigor found in manufacturing operations.

When the service system involves knowledge-intensive activities, qualified human capital grows in importance, as well as the need to strategically manage its large volumes of information and knowledge.

Service operations knowledge is crucial for bringing positive outcomes and superior organizational performance. Knowledge Management is the discipline that addresses those issues, studying knowledge identification, acquisition, storage and transfer in organizations (Davenport & Prusak, 1998). Organizational learning, positive experience reproduction, risks management related to turnover and efficiency increase in service execution are among the benefits of knowledge management initiatives.
However, knowledge management strategies, methods and tools must not operate in an isolated manner; they should be fitted into system service structure and processes. Support to knowledge management initiatives needs to be considered in the service system design phase.

The design phase is essential for goods and services development and management, establishing how the requisites will be incorporated in the final product. In service design, several aspects need to be considered, related to supporting facilities, facilitating goods, processes, technologies, organizational structure and workforce (Gianesi & Correa, 1994). More or less, these aspects are influenced by the knowledge management model in use.

Thus, how can the effects of the knowledge management model be visualized before service production, in the service design phase? In manufacturing process design, it is common to evaluate scenarios and alternatives related to product development. However, in service design, due to its intangible nature, this evaluation is harder, making scenario-testing more difficult. While, in goods production is common to build physical models that materialize the conceived ideas, service design may use simulation techniques.

According to Banks (2000), simulation imitates the operation of a real-world process or system during a period of time, based on the creation of an “artificial history” of the system, where outcomes may help to infer real system operations. For Sheu et al. (2003) simulation offers important advantages above other mathematical tools, like value-ranges flexibility in controlled parameters and real system behavior capture.

This paper proposes the use of System Dynamics as a support tool in service system design, highlighting the knowledge management effects on system’s behavior. Created by J.W. Forrester in late 1950s, System Dynamics allows complex system simulation through stock and flow metaphors.

In this sense, the technical support service of a software-house was modeled. This activity has been described by the literature as knowledge-intensive and human-based. Through the use of a system dynamics model build in iThink® platform this paper demonstrates how a service designer can: i) evaluate Human Resource (HR) alternatives based on their demand; ii) simulate the effects of knowledge management on the future system’s operation; iii) evaluate system’s behavior under different demand conditions.

The next section deals with service system design, highlighting the need to promote knowledge management initiatives when it is considered a requisite. Third section develops the system dynamics concepts used in the model. Model application is developed in Section 4, considering a knowledge-intensive service system design in a software-house. Finally, in Section 5, the conclusions of the paper are presented.

Service System Design

Similarly to goods manufacturing, service operations are composed of several components. However, these components are mainly non-physical, characterized by a combination of processes, human competences and other resources (Goldstein et al., 2002). In new service development or in service re-design, managers and designers must make decisions with different levels of complexity about each component of the service (Goldstein et al., 2002)

For Gianesi & Correa (1994), the main decision areas in service system design are: i) the service package, dealing with the supporting facilities, facilitating goods, implicit and explicit services; ii) the processes and technologies adopted; iii) facilities’ localization and layout; iv) workforce; v) organizational structure. This paper sheds light on workforce demand and knowledge management effects on service system design.

Service system design has been pointed out by Chase & Apte (2007), Hidaka (2006) and Maglio et al. (2006) as a promising research field, considering also, the relevancy of simulation and modeling techniques in helping analyzing these tasks.

1 iThink is a registered trademark of Isee Systems Inc. (www.iseesystems.com).
Heineke & Davis (2007) discuss the relationship between the need for global service expansions and the use of information and communication technologies with geographically dispersed resources. These factors establish new challenges for service managers and increase the importance of design and monitoring tasks for high quality services.

Reinforcing the importance of investing in adequate HR management, constituting an essential asset in service organizations, Dial (2007) points out that, in contrast to manufacturing operations, services are highly dependent on operator’s experience and intuition, thus, having an inferior overall productivity than of manufacture activities. The author suggests the adaptation and application of manufacture concepts and methodologies in service operations in order to raise productivity indicators.

This paper – supported by the ideas exposed – recognizes the importance of knowledge management in service operations, and points out the need to guarantee the necessary resources in design phase. System Dynamics, as detailed in the next section, is explored as a tool that seeks to help designers and to foresee system’s behavior for each project scenario, and more importantly, to analyze the effects of knowledge management initiatives in the service operations.

**System Dynamics**

System Dynamics (SD) was developed by J. Forrester in 1961 (Forrester, 1989), as a methodology for understanding complex systems behavior, through soft and hard simulation. According to Sterman (2000) “System Dynamics is a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System Dynamics is also a rigorous modeling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations”.

It evolved from the application of control theory to the study of dynamic social systems its premise is that the behavior of a complex dynamic system is the result of the structure (causal relationships, feedback loops and time delays) (Sterman, 2000; Oliva & Sterman, 2001). Feedback loops are defined by information acquisition over system state and for actions causing changes in that state. Its modeling involves accumulation processes (stocks) and flows, as well as time delays and non-linear relationships. (Gonzalez & Dutt, 2007).

Sengir et al. (2004) discuss the importance of System Dynamics for behavior and structure analysis in social systems. Feedback loops, differentiate System Dynamics from other approaches, by characterizing non-linear social relationships. Stocks and flows of information, people and other resources allow the study of systems with high levels of dynamic complexity and the study of timing issues in organizations.

Some of the advantages brought by this approach in modeling complex dynamic systems are listed by Hollmann & Voss (2005): i) “stock and flow” diagrams provide and intuitive vision above the structure of the system in study; ii) all the dependencies and relationships are visualized graphically, facilitating the understanding of the processes; iii) simulation tools like iThink, allow model variables modification interactively, in a so-called “control panel”, facilitating scenario-testing and analysis.

**Some lessons from the field**

This section illustrates the use of a system dynamics model as a support tool for service system design, emphasizing the possibility to simulate the knowledge management effects over the system performance. The service analyzed from the practical field is a technical support service
Opening requests are received via telephone and e-mail. Telephone support service has priority over e-mail support service.

The objective of the system is to reach zero non-attended telephone calls at the end of the day.

E-mail inbox is shared across the attendants and it is also desirable to be zero (0) at the end of the day.

Knowledge management: at the end of a service, the attendant responsible should feed the knowledge-base, aiming at making forthcoming services more agile.

It is beyond the scope of this paper to define the knowledge management strategies and tools used in the company. The term “knowledge base” is used in this paper to represent a knowledge repository that grows as the feeding process goes on. It is expected that this knowledge repository will facilitate future attendances, if supported by adequate knowledge representation, retrieving and reusing techniques.

Besides improving service system performance, the establishment of a knowledge base must facilitate rookies training, reducing the expected effects of turnover. In knowledge-intensive activities, such as technical support services, this aspect is of fundamental importance, since attendants must accumulate a large volume of knowledge - regarding functional characteristics of the software as well as content ones - in order to successfully execute the activity.

The example used aims to demonstrate that the structure needed to promote knowledge management initiatives is a part of service system design and that – as the rest of its components – it represents operative and financial costs that must be compensated or, preferably, being overcome by the benefits brought by its use. The developed System Dynamics model helps the service designer in evaluating these cost-benefit ratios by considering several demands versus capacity scenarios.

**The Model**

Exhibit 1 shows the model developed in iThink software. The modules that constitute it are briefly described below:

- **Phone Support**: the number of calls received daily is regulated by the \textit{ReceivingPhoneCalls} inflow. The stock \textit{PhoneSwitch} is emptied by \textit{AnsweringCalls} and \textit{LosingCalls} outflows, this last-one represents excessive demand. The phone calls effectively answered are accumulated in the \textit{CallsAnswered} stock, that are finalized through the \textit{EndingCall} outflow until they are stored in the \textit{KnowledgeBase} stock.

- **E-mail Support**: \textit{IncomingEmail} flow feeds daily the \textit{EMailInbox} stock. Differently from phone-calls, e-mail inbox doesn’t necessarily empties-out, since it doesn’t count with an outflow other than \textit{ReplyingEmail}. The amount of emails answered each day depends on the remaining time the attendants have after answering all of the phone-calls. The \textit{EndingEmail} flow process emails through the \textit{KnowledgeBase} stock.

- **Knowledge Management**: The \textit{KnowledgeBase} stock is feed-up via both answering types and doesn’t present outflows in this version of the model.

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2 AltoQi Tecnologia em Informática develops and sells building-design software. It is established in Florianópolis, Brazil with more than 15,000 clients.
Dynamic complexity of the model is also regulated through a series of variables representing several activities. The variables Attendants, AverageCalls and AverageEmails are controlled directly by the designer, facilitating scenario testing and evaluation. Exhibit 2 shows the Control Panel that constitutes the model user’s interface. Other variables like CallingTime follow a probability distribution, establishing the time spent on each technical support call, as a uniform distribution between 5 and 15 minutes.

In the knowledge management sub-model, the amount of knowledge stored affects directly the variable AttendantsQuality that determines service time-reduction (TimeReduction). On the other hand, the use of the KnowledgeBase increases serving time by MemorizationTime. This means that, in spite of bringing benefits in the long-term, the Knowledge Management structure will initially bring costs rather than benefits. It is expected that the simulation model will help the designer in cost/benefit evaluations related to knowledge management initiatives in the system’s operation.
The Simulation

Exhibit 3 shows the simulation outcomes for a 30 day period, considering a low knowledge stock accumulated. In this scenario, a variable $\text{AttendantsQuality}$ is with a value of 1 among a continuous scale 0-5. The variables monitored are $\text{LosingCalls}$ (pink), $\text{EMailInbox}$ (green), $\text{AnsweringCalls}$ (blue) and $\text{ReplyingEmail}$ (red). This scenario considers eight attendants for a daily demand of 200 calls and 90 e-mail messages.

Lost calls, in Exhibit 3, represent high numbers in most of period, and the attendants’ team cannot maintain $\text{EMailInbox}$ close to zero. Thus, two important requirements of the service system are not met.

A different scenario was simulated considering a high level of knowledge stock, with $\text{AttendantsQuality}$ near maximum value (5). Exhibit 4 shows that the quantity of lost calls is close to zero as well as the e-mail volume received daily.

The outcomes presented in both simulations help the service designer in justifying knowledge management initiatives as part of the service system.
Conclusions

Flexibility in service operations and design-ability are the fundamental requirements of modern day service sectors. In today’s customer driven market, these requirements are of paramount importance more than ever before.

This paper has tried to demonstrate the usefulness of simulation techniques, such as System Dynamics, in service system design. Specifically, it aimed to analyze the effects caused by a knowledge management initiative in a technical support service. It concludes that knowledge management implementations should be analyzed earlier in the design phase, supported by simulation techniques for scenario-testing and evaluation. The System Dynamics model was developed using real data of a software-house. This data was used to create two different scenarios, showing the importance of knowledge management initiatives in knowledge-intensive activities.

The results have indicated that parameters such as KnowledgeBase and AttendatsQuality do have significant influence on the service quality in knowledge-intensive service systems. This paper delineates the fact that a System Dynamics approach can be a powerful tool in enhancing the effectiveness of service system design.

Even though this paper culminates in the recommendation of using simulation techniques for service system design in the studied field, it calls for future extension of this research into the specific details of knowledge conversion, i.e. the SECI model of Nonaka and Takeuchi (1995) so as to facilitate the storage of knowledge in the KnowledgeBase; as well as processes such as organizational forgetting and un-learning that outflows the KnowledgeBase stock. There is also enough scope to add new variables (e.g. organizational culture factors, motivation issues, demographic influences, etc.), which influence service system design, into the technical support dynamics in knowledge-intensive service systems and carry out simulation.

References


