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8P. A Proposal for Metrics of Organizational Knowledge Creation based on a Simulation Model

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Abstract

This working paper aims to present the progress in the construction of a survey instrument for validating the results of a simulation model for organizational knowledge creation. Azevedo et al. (2010) developed a computer simulation model based on the contributions of March (1991), and incorporating aspects of Nonaka & Takeuchi's (1997) SECI model to measure the knowledge generated in an organization. The model uses seven parameters to analyze knowledge generation: (i) the speed of socialization of the individual with the code of the organization; (ii) the effectiveness of the organization to learn; (iii) the turnover; (iv) the existence of market turbulence; (v) the adhesion of an individual to the code of the organization before he is hired; (vi) the influence of the market; and (vii) the influence of one individual to another. Based on the model, a survey instrument is being developed in order to evaluate the parameters in an organization and to compare the results of scenarios generated by the simulation with data from organizations. At this stage of the research, the discussion focuses on the different constructs that compose a parameter and the sets of statements that can express those constructs.

Keywords

Knowledge creation, Simulation, Learning models, Organizational learning, Survey.

1. Introduction

For more than three decades, organizational learning has been discussed, not only as a source of competitive advantage for the sustainability, but also as a prerequisite for innovation in

products and processes (Azevedo et al., 2010). Due to the relevance of the theme, researchers around the world are seeking techniques and metrics that enable organizations to assess the knowledge they possess and thereby distribute efforts on creating, using and managing knowledge. James March (1991) contributed to the field by proposing a model of Mutual Learning, while Nonaka & Takeuchi (1997) presented the SECI Model, which states four different ways of creating and converting knowledge.

March (1991) presents a stochastic model for learning processes in organizations. The model aims to elucidate some of the relations between exploration of new possibilities and exploitation the old certainties in organizations. The question addressed is how organizations choose between these two approaches and how they can improve the balance between them. March (1991) relates the concepts of exploration and exploitation with the process of acquiring knowledge by organizations. The model he proposed, called 'Mutual Learning', is based on the idea that organizations accumulate knowledge - in the form of procedures, standards and rules - learned from its members, while individuals in an organization are socialized with the beliefs of that organization. The main features of this model are:

- the existence of an external m -dimensional binary $(-1, 1)$ reality, whose values have equal probabilities of occurrence and whose dimensions are independent;
- the consideration of the beliefs, of the individuals and the organization, through a code of understanding of reality. These beliefs take the values $(-1, 0, 1)$, mimicking dissent, indifference or agreement with each dimension of a reality previously established;
- a probabilistic framework for learning mechanisms in which:
 - individuals have a probability p_1 to modify their beliefs every time the organization has a different and non-neutral belief, in a given dimension. So, p_1 represents the effectiveness of the socialization of an individual in the organization;
 - on the other hand, the organization learns as its code has a probability $p_{2,k}$ to adapt to the beliefs of individuals in a group called 'superior', i.e. individuals whose beliefs match reality in more dimensions than those of the organization. In this case, p_2 indicates the effectiveness of the organization to learn and k is an indicator for the percentage of individuals of the superior group that differ from the code in each dimension.

Furthermore, the model considers that the beliefs of an individual not directly influence the beliefs of others and that the effects of reality are indirect, i.e., neither individuals nor the organization experience reality directly, and improvement in knowledge comes from the code to mimic beliefs (including the false ones) of superior individuals, and from individuals that imitate the organization's code (including its false beliefs). Based on this model, March (1991) generates a series of scenarios, which start with a neutral position on all dimensions of the code of the organization and a set of individuals with varying beliefs that, on average, represent no knowledge.

Azevedo et al. (2010) developed a computer simulation model based on the contributions of March, but incorporating aspects of Nonaka & Takeuchi's SECI model to measure the knowledge generated in an organization. The model proposed by Azevedo et al. (2010) uses the same parameters presented by March (1991): 30 dimensions of reality, 50 individuals and 80 replications. Each replication progresses in a time horizon of 100 periods. Also the same names of parameters were used, in order to facilitate the understanding of the model.

At this phase of the research, the simulation model of Azevedo et al. (2010) has generated scenarios of dynamic organizational learning and one of them is illustrated in this article. The results were tested at a significance level of 5%, with parametric tests of comparison of means. Nevertheless, in order to provide empirical validation for the results of those scenarios, it is necessary to collect data in the real world. To do so, a survey instrument is currently being developed to collect data from organizations and to serve as a base for testing and refining the model. This article presents a partial development of the instrument, in order to promote its discussion in the academic community.

This paper is constructed as follows: the next sections present some extra information about the SECI model (Nonaka & Takeuchi, 1997; Takeuchi & Nonaka, 2008) and the developed model (Azevedo et al., 2010). Then information about the constructs and questions currently being developed for the survey are briefly discussed. Finally, further steps of the research are presented.

2. The SECI Model

One of the major contributions that Nonaka & Takeuchi (1997) provided to the subject of knowledge management was the SECI model, which is composed of four forms of knowledge conversion:

- Socialization (S): stands for the communication between individuals, the attempt to share knowledge through informal experiences, almost like conversations made on a daily basis. It is the conversion of tacit knowledge into tacit knowledge;
- Externalization (E): stands for the quest of the individual on transmitting his/her knowledge to a larger group. To facilitate such transmission, he/she can try to use metaphors and analogies. It is the conversion of tacit knowledge into explicit knowledge;
- Combination (C): stands for the transfer of knowledge acquired by one group to the organization in the form of rules, documents, methods, working procedures, systematization of concepts. It is the conversion of explicit knowledge into explicit knowledge;
- Internalization (I): stands for the incorporation of the knowledge contained within the organization by its individuals. This appropriation of organizational concepts generates new knowledge. It is the conversion of explicit knowledge into tacit knowledge.

Condition	Definition
Intention	Knowledge driven to the goal of the company. Individuals must be familiar with the visions and missions of the company. These should be in accordance to the individual wishes.
Autonomy	Autonomy must be given at the individual level, increasing the chances of individuals to feel motivated regarding the knowledge creation.
Fluctuation and Creative Chaos	The company should interact with the external environment. It is interesting for the company that there is some fluctuation in the environment so that the employees are always concerned about how to solve new problems. If the environment is very stable, the organization itself may induce a creative chaos, offering exciting new goals or simulating a crisis situation.
Redundancy	In the sense that information is provided beyond the immediate demands of the members of the organization.
Variety of Requisites	Information easily accessible and for everyone in the company; multifunctional knowledge; professionals from different fields working together.

Table 1: Conditions which promote the knowledge spiral (Nonaka & Takeuchi, 1997).

The interaction of these four forms of knowledge conversion is what Nonaka & Takeuchi (1997) called Knowledge Spiral. The knowledge acquired through Socialization is relayed to

the group through the Externalization, and turned into standards and methods through Combination which is, again, passed on to individuals through Internalization, which will generate new knowledge from those in the organization. It generates, then, a continuous cycle of creation and dissemination of knowledge.

Nonaka & Takeuchi (1997) also claim that there are five organizational conditions that promote the knowledge spiral. Table 1 briefly explains these five premises, which also served as reference in the development of the proposed survey instrument.

3. The Simulation Model

As stated before, the model developed by Azevedo et al. (2010) extends the model of March (1991) by using the concepts developed by Nonaka & Takeuchi (1997). Three new parameters were included:

- To expand the concept of Internalization and analyze the effects of selection of new individuals on the knowledge acquired, a p_5 parameter was created to represent at what extent the beliefs of new individuals should be similar to the organization for them to join the organization;
- To represent the Combination, the notion of influence of the market in the organization was adopted and a m-tuple was created to indicate the set of beliefs about reality shared by the market in which the organization operates. This code assumes values (-1, 0, 1), which have equal probabilities of occurrence, and its dimensions are independent. A probability p_6 of the code of the organization be affected by the belief of the market was set;
- To represent the Socialization, the notion of zone of influence of each individual over the others in the organization was created. As the transfer of tacit knowledge requires physical proximity (Nonaka & Takeuchi, 1997), limiting the area of influence is necessary. Thus it was assumed a zone of influence representing 10% of the total of individuals. The power of influence is given by p_7 , which represents the probability of an individual to influence another person close to him.

So, in total, seven parameters were used: (i) the speed of socialization of the individual with the code of the organization, called " p_1 "; (ii) the effectiveness of the organization to learn, " p_2 "; (iii) the turnover, " p_3 "; (iv) the existence of market turbulence, " p_4 "; (v) the adhesion of an individual to the code of the organization before he is hired, " p_5 "; (vi) the influence of the market, " p_6 "; and (vii) the influence of one individual to another, " p_7 ".

Table 2 presents a comparison between the SECI model (Nonaka & Takeuchi, 1997), the Mutual Learning model (March, 1991) and the model presented by Azevedo et al. (2010).

The proposed model allows the analysis of different configurations of the scenarios, which leads to various reflections on organizational learning and creating knowledge processes. An example of the results generated by the simulation model can be seen in Figure 1, where the variation of the parameters p_1 and p_7 generates different levels of organizational knowledge. To generate this figure, parameter p_2 was set as 0.5, and parameters p_3 , p_4 , p_5 and p_6 were set as 0. This simulates the impacts in the organizational knowledge of individuals with various rates of socialization with the organization code and different levels of influence over coworkers, in a situation where there is no turbulence, no market influence and no turnover, and the organization's learning rate is medium. In such context, simulation indicates that the organization tends to benefit from low rates of influence between individuals ($0.05 < p_7 < 0.4$), to the extent that they have a low rate of socialization with the code of the organization

($0.1 < p_1 < 0.4$) – this is the situation in which higher levels of knowledge are reached. On the other hand, a high rate of socialization with the code of the organization ($0.6 < p_1 < 1.0$) combined with a low rate of influence between individuals ($0.05 < p_7 < 0.2$) doesn't promote higher levels of knowledge – the possibilities of exploration are limited. One can infer that, as the adaptability of individuals to the code of the organization increases, more socialization among individuals will be beneficial, until some limit.

SECI model	Mutual learning model	Proposed model
Socialization	-	zone of influence p_7 , individual's power of influence
Externalization	p_2 , learning rate of the organization	p_2 , learning rate of the organization
Combination	-	set of beliefs of the market p_6 , market's influence
	p_4 , environmental turbulence	p_4 , environmental turbulence
Internalization	p_1 , "socialization" of individuals with the organization's code	p_1 , "socialization" of individuals with the organization's code
	p_3 , turnover	p_3 , turnover p_5 , adherence to the organization's code

Table 2: Comparison between the main characteristics of the models.

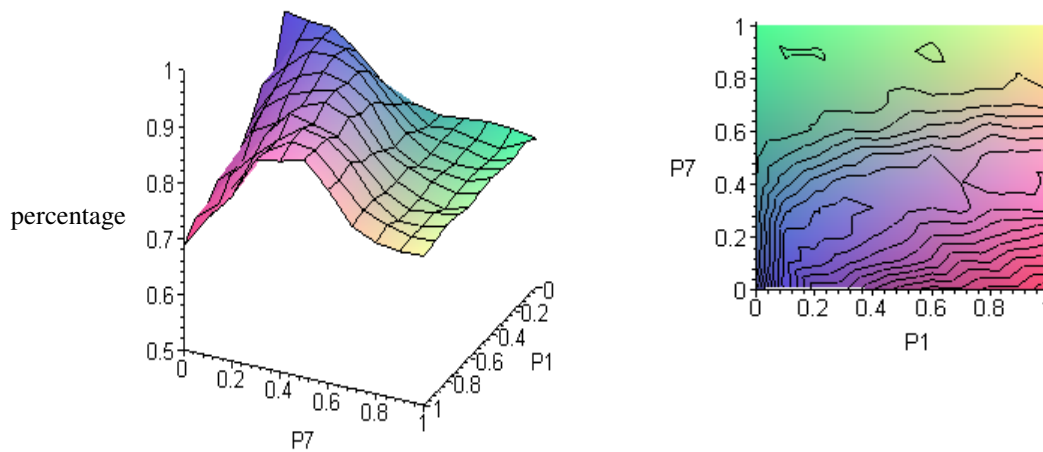


Figure 1: Organizational knowledge after steady state, as function of p_1 and p_7 ($p_2=0.5$, $p_3=p_4=p_5=p_6=0$).

4. The Development of Metrics

In order to compare the results obtained in the simulation model with the reality of companies an exploratory survey will be performed. As proposed by Hair et al. (2009), the questionnaire is an appropriate tool for conducting the survey. The research is classified as exploratory, because the goal is to become familiar with the matter and discover new possibilities and dimensions of the population of interest. The aim is to develop a questionnaire with sets of statements, representing the constructs regarding each simulation parameter. The statements

will be followed by a Likert scale of 5 points (Cooper & Schindler, 2003), representing from full disagreement to full agreement. It is expected that the respondents, based on the statements, indicate their degree of agreement on the issue, according to their perceptions.

So far, a research based on references about metrics for each form of knowledge generation (Bose, 2004, Harlow, 2008; Haldin-Herrgard, 2000, among others) was performed. These metrics were related to the parameters of the simulation model. Also, for each parameter of the model, where defined the main constructs, based on the references about metrics of knowledge and on March (1991) and Nonaka & Takeuchi (1997). In this short paper are presented the constructs and the sets of statements for three parameters: p_1 , p_2 and p_7 .

For p_1 , Internalization, to identify the potential of individuals to be socialized with the organization's code, four constructs were generated. Two of them address personal characteristics and are named "motivation for work" and "individual flexibility". The other two reflect organizational aspects, being named "pressure from the organizational culture" and "knowledge offer". The research group conjectured that the individual has the ability to adapt to new realities by itself and also there are stimuli offered by the organization which can make him/her more likely to internalize new knowledge.

P_1 – Socialization of the individuals to the code of the organization Represents Internalization (conversion of explicit knowledge into tacit knowledge)	
References: Bose (2004); Liebowitz (2000); Nonaka & Takeuchi (1997).	
Constructs	Statements
MOTIVATION FOR WORK	<ul style="list-style-type: none"> - I see my work as important and challenging. - The company rewards those who reach the goals/visions established. - A pleasant, organized and clean environment motivates learning. - I get feedback from my activities. - I seek ways to improve the performance of my duties. - I am proud to talk about my activities to others.
INDIVIDUAL FLEXIBILITY	<ul style="list-style-type: none"> - At the beginning of my activities in the company, I adapted easily to the existing rules in the company. - I am flexible to adapt to company changes. - I had no difficulty to adapt to the rules of the company. - Changes are good, as they allow growth opportunities. - I see new processes as learning opportunities. - The biggest problem with a change of position or function is that you have to learn all over again. - I am proud to have incorporated/incorporate the company values.
PRESSION FROM THE ORGANIZATIONAL CULTURE	<ul style="list-style-type: none"> - The vision, mission and values of the company influence my work. - I've changed my personal goals to adapt better to the goals of the company. - When I entered to the company I felt the need to "join the team". - I find the pressure to perform activities in a standardized way a nuisance.
KNOWLEDGE OFFER	<ul style="list-style-type: none"> - The company has a schedule of training and development activities that contributes to my performance at work. - I use the company's database/intranet as a source of information. - I have access to information related to the strategy and the goals of the company. - I am invited to discussions about strategy and directions of the company. - The most experienced staff work in programs for training new employees. - When I joined the company, I received formal training to exercise my activity. - The meetings are opportunities to access knowledge that helps me in my activities. - I learned to perform my tasks through documents available within the company. - The manuals provided by the company supply all my needs. - I learned to perform my duties by observing my co-workers.

Table 3: Constructs and statements for p_1 .

P ₂ – Effectiveness of the organization on learning from individuals Represents Externalization (conversion of tacit knowledge into explicit knowledge).	
References: Harlow (2008); Anantatmula & Kanungo (2006), Nonaka & Takeuchi (1997)	
Constructs	Statements
KNOWLEDGE DIFFUSION	<ul style="list-style-type: none"> - I have access to procedures and standards of the department where I work. - I provide support for creating or updating procedures and standards of the department where I work. - I provide support for creating or updating procedures and standards of other departments of the company. - The rules and procedures of the company are periodically updated to meet the practices. - The company encourages that the knowledge acquired by a department or a person to be shared with all others. - The middle managers have great influence in the dissemination of knowledge acquired by the company to the employees.
COMUNICATION CHANNELS	<ul style="list-style-type: none"> - I receive/send information about events in the company through e-mail, intranet, newsletters or other communication channel; - The company uses a formal system that seeks to assist communication between departments and employees; - Through a formal program of suggestions, I can contribute to improve the work environment, the products and the services of the company. - Besides of the formal program of suggestions, there are other spaces that encourage my participation and contribution. - There are formal and structured processes to share knowledge.
USE OF TECHNOLOGY	<ul style="list-style-type: none"> - The company provides software that help disseminate information to carry out my activity. - The rules and procedures of the company are updated through electronic means. - The company is concerned in maintain an updated database. - The stored information is used to facilitate processes, assist the decision-making and promote organizational learning. - The company encourages and sponsors specialization, master and doctorate programs for their employees.
EXPOSITION OF INDIVIDUAL'S IDEAS	<ul style="list-style-type: none"> - In my work, the use of metaphors or analogies is accepted as an expression of ideas or ways of thinking. - In general, suggestions are welcome and, if the company deems appropriate, are applied. - The company values new ideas that arise from the employees. - The company encourages employee empowerment. - The company supports projects created or suggested by its employees.

Table 4: Constructs and statements for p₂.

For p₂, Externalization, to identify how the organization can capture the knowledge generated by individuals and take advantage of it, four constructs were created: “diffusion of knowledge”, “communication channels”, “use of technology” and “exposition to ideas of individual”.

As for p₇, Socialization, to access individual’s power of influence, three constructs were generated: “influences of the organizational environment”, “influences of the physical environment” and “interaction of individuals”. For the other parameters considered in the model, constructs are still being analyzed. Finally, for each construct created, a set of statements was developed, based on the literature. A summary of the statements for each parameter, and the main references are presented in Tables 3, 4 and 5.

P ₇ – Influence of one individual to another Represents Socialization (conversion of tacit knowledge into tacit knowledge).	
Authors: Harlow (2008); Haldin-Herrgard (2000); Nonaka & Takeuchi (1997)	
Constructs	Statements
INTERACTION	<ul style="list-style-type: none"> - I often assist my colleagues in their activities and they in mine. - In the company, usually more than one person solves the problems. - I have oportunities to affect the work of those around me. - New knowledge/working practices are passed from one employee to another. - Difference of ideas promotes healthy interactions. - I have freedom to talk with my colleagues during the course of my activities. - Most of my co-workers are my friends.
INFLUENCES OF THE ORGANIZATIONAL ENVIRONMENT	<ul style="list-style-type: none"> - The company forms project groups with professionals from different areas. - The company seeks to promote job rotation. - The company promotes activities outside the work environment (events, gatherings). - In the company the activities are carried out by teams. - In my work I have freedom to make decisions without needing the support of my colleagues.
INFLUENCES OF THE PHYSICAL ENVIRONMENT	<ul style="list-style-type: none"> - In the company there are no physical barriers that prevent dialogue with my colleagues in the department. - In the company the environment is relaxed, facilitating and promoting communication between people. - The communication between groups is facilitated through the use of IT. - Tasks are delegated personally to employees and not through e-mail or other impersonal ways. - In the department where I work there is a common room/space for coffee, snacks and informal meetings.

Table 5: Constructs and statements for p₇.

5. Validation and Surveying Issues

As presented earlier, this is an ongoing research project. The proposal of metrics presented in this short paper will be complemented with profile questions and descriptive questions about the knowledge creation in order to prepare a structured survey instrument. The complete instrument will be presented to five specialists on organizational learning, although the proposal of this partial work serves as a pre-validation from the research community.

After validation, a pilot test will be performed with samples of 100 employees of two companies, in order to collect data which could represent the modes of organizational knowledge generation as presented before. For each construct, data will be checked for consistency by using Crombach's alpha coefficient (Hair et al., 2009). The data will be converted to a [0;1] interval by a linear average function. Results will be analyzed and confronted to the results predicted by the model of Azevedo et al. (2010). Results will also be presented to representatives of the companies surveyed for a qualitative analysis and in depth interviews will be performed in order to evaluate the adequacy of the predicted results. After this cycle of analysis, further refinements will be proposed and a new survey will be performed.

6. Future Work

This paper presented the current work regarding the construction of a survey instrument to produce empirical evidences of validity for a simulation model of organizational knowledge creation. The work was presented, although unfinished, as a form of receiving contributions from the academic community.

The proposal of metrics presented here is currently on development. The next steps are to finalize the survey instrument, to pre-test it and, after consolidation and refinements, to make it available to medium and large size Brazilian companies. A discussion still to be addressed is the need to consider different weights for the constructs of each parameter. Based on statistical analysis of the respondents, the model will be tested for its consistency and ability to support analysis, and a new article will be developed for the presentation of results.

References

- Anantatmula, V. and Kanungo, S. (2006) “Structuring the underlying relations among the knowledge management outcomes”, *Journal of knowledge management*, (10)4, pp. 25-42.
- Azevedo, D., Vaccaro, G. L. R., Lima, R. C. S. and Silva, D. O. (2010) “Um estudo de simulação computacional para a análise de perfis de aprendizagem organizacional”, *Produção* (accepted for publication).
- Bose, R. (2004) “Knowledge management metrics”, *Industrial Management & Data Systems*, (104)6, pp. 457-468.
- Cooper, D.R. and Schindler, P.S. (2003) *Métodos de Pesquisa em Administração, 7th edition*, São Paulo: Bookman.
- Haldin-Herrgard, T. (2000) “Difficulties in diffusion of tacit knowledge in organizations”, *Journal of Intellectual Capital*, (1)4, pp. 357-365.
- Hair, J. F.; Anderson, R. E.; Tatham, R. L.; Black, W. C. (2009). *Multivariate data analysis. 9th edition*, Porto Alegre: Bookman.
- Harlow, H. (2008) “The effect of tacit knowledge on firm performance”, *Journal of Knowledge Management*, (12)1, pp. 148-163.
- Liebowitz, J. (2000) “Developing knowledge management metrics for measuring intellectual capital”, *Journal of intellectual capital*, (1)1, pp. 54-67.
- March, J. (1991) “Exploration and exploitation in organizational learning” in Cohen, M. and Sproull, L. (eds.) *Organizational Learning*, Califórnia: Sage, pp. 71-87.
- Nonaka, I., Takeuchi, H. (1997) *Criação de conhecimento na empresa*, Rio de Janeiro: Campus.
- Takeuchi, H; Nonaka, I. (2008) *Gestão do conhecimento*, Porto Alegre: Bookman.