The representation of knowledge by means of dynamic systems

A representação do conhecimento por meio de sistemas dinâmicos

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RESUMO

Este trabalho tem como objetivo representar a variação do conhecimento coletivo gerado em um determinado grupo. Como o conhecimento é intangível, há certa dificuldade em representá-lo e o processo apresentado nesta pesquisa possibilita sua explicação. O caso estudado foi um coletivo de mulheres pescadoras da região de Guaraqueçaba, Paraná - Brasil. Como procedimento metodológico utilizou-se uma pesquisa bibliográfica e a conclusão é que há um crescimento do conhecimento com as interações e um decréscimo, pois um dos atores deixou de participar da rede.

Palavras-chave: Sistemas dinâmicos; Conhecimento Coletivo; Pescadoras de Guaraqueçaba; Teoria Ator-Rede; Redes

ABSTRACT

This paper objective is to represent the variation of collective knowledge generated in a given group. As knowledge is intangible, there is some difficulty in representing it and the process presented in this research makes possible its explanation. The case studied was a collective of women fishers from the region of Guaraqueçaba, Paraná - Brazil. As a methodological procedure we used a bibliographical research and The conclusion is that there is a growth of knowledge with the interactions and a decrease because one of the actors stopped participating in the network.

Keywords: Dynamic Systems; Collective Knowledge; Fisherwomen from Guaraqueçaba; Actor-Network Theory; Networks.

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INTRODUCTION[1]

Knowledge comes from the perception of the world, through experiences, independent of the relationships, associations or interpretations made by individuals (Tomael, 2005). Knowledge is resulted, and constructed from experience, in the conceptions of Polanyi (1966) and Nonaka (1994) and the different relationships established. If relationships change, the definition changes, and then there is knowledge (Latour, 2012). Knowledge makes individuals to develop a more critical sense and can change their attitudes towards the world (Reis, 2014).

It is believed that knowledge is built through networks with interaction between people. This social structure, sharing the same codes of communication, causes knowledge to occur and this can be demonstrated through Dynamic Systems.

Dynamic systems can be the support for the evaluation and strengthening of public policies. Bardach (2006), political scientist, concentrates his studies in the implementation of management and public policies, specifically in the dynamics of the policies. It states that not all systems are dynamic, but all dynamics occur within systems, because there are interactions and they modify dynamics (Bardach, 2006).

From this approach, Sterman (2000) states that after the elaboration of a dynamic system, it is necessary to perform tests with the data informed from the reality. In this way it is possible to structure, policy and evaluate the creation of new strategies, structures and rules for decision making in an appropriate way.

Considering this scenario, this research was carried out to assist in the understanding of how the knowledge generated in a given group could be represented, since the models used in dynamic systems present concrete and measurable data. The chosen group was a group of women fishers from the region of Guaraqueçaba, the target audience of the research, in order to map how the process of knowledge construction in this system happens.

With the accomplishment of this work, it was observed that knowledge is given increasingly and even if there is a loss of this knowledge, it will always be on a smaller scale than the acquisition; the use of simulation software was of substantial help in reaching these conclusions in an exempt manner.

The text of this article is divided in the presentation of concepts regarding knowledge, networks and systems; in the description of the system modeling process and its representations through flows and graphs, analysis and inferences, and finally, the conclusion is presented.

LITERATURE REVIEW

The literature review, which bases the analyzes and the results, begins with the conceptualization of knowledge, especially in the understanding of Polanyi (1966) and Nonaka (1994), passes through minimum concepts of the Theory-Actor Network (TAN), element theoretical and methodological and ends in the systems modeling processes.

[1] Versão para o inglês de Giovanni Francesco Mandelli.

The Knowledge

Knowledge is something intrinsic to the person and is done in social contexts and individuals. For Polanyi (1966), knowledge or discovery is not the result of organized rules; It is built by human beings and is charged with emotion, passion, meaning, and therefore largely personal; All knowledge is tacit and comes from *praxis*.

In his study of tacit knowledge, in the light of Polanyi (1966), Lage (2013, p.50) concluded that:

> The main contribution of Polanyi is the conception of a human knowledge model that integrates perception and apprehension of meanings from the practical formatting of experiences. Knowledge is constructed from physical processes, in the interaction of the body with the things with which we confront each other, converted into an understanding of the intellectual and practical meaning of the world around us. Knowledge is integrated, internalized, embedded, and therefore intrinsically associated with the knower and not depersonalized.

Nonaka and Takeuchi (1997) emphasize that the fundamental importance of the theory of knowledge in the differentiation between tacit and explicit knowledge and the secret to the creation of knowledge lies in the mobilization and conversion of tacit knowledge into explicit knowledge. They show that knowledge, which is individual, insofar as it is explicit can be shared, transforming itself into knowledge of group and even of society (Nonaka; Takeuchi, 1997).

Knowledge has no limits in Drucker (2002), it is acquired by the individual, is not inherited or granted. Drucker (2002) called the current society of Knowledge or Information Society and says that its success comes from information, an essential element for the permanence of organizations in the market. If individuals have the information beforehand, they will be more likely to develop, create, and position themselves ahead of their competitors (Drucker, 1994).

This information, this knowledge, belongs to people connected to the organizations and is called Intellectual Capital. Stewart (1998, p. XIII) brings the concept of intellectual capital, which is "the sum of everyone's knowledge in a company, which gives it competitive advantage." Intellectual capital can be used to generate wealth, being considered as one of the most important intangible resources of organizations (Strauhs, 2003).

In 1998, Nonaka in partnership with Konno, perfected a model of organizational knowledge creation, the SECI model, adding to it the concept of Ba. Ba is a collective space where knowledge creation takes place and means "place" (Nonaka and Konno, 1994).

For Nonaka (1998) "Ba" is a shared space, which can be physical like offices, classrooms; e-mails, teleconferences, and even mental as shared experiences and ideas. This space, also called the enabling context, is an aggregator of creation of knowledge par excellence, a space of social interaction, a space in network and in constant movement and change.

Networks and The Actor-Network Theory – some principles

In view of the definitions presented so far, it is observed that the concepts of Latour (2012), Polanyi (1966), Nonaka (1994), Drucker (1994) and Stewart (1998) are aligned.

"There is more to experience than what comes to our eyes" (Latour, 2006, p. 160), and from this assertion that the alignment with the actor-network theory (TAN) is made, since it does not have a pre-structured or closed network configuration. TAN describes the actors that make up the network because they interact and exert influence over one another, this mobility between beings and things confronts society, the actor and the network (Latour, 2006, 341). Therefore, a network is formed by everything that can contribute to its interaction and to obtain a product called knowledge (Latour, 2006). This theory allows us to analyze science, technology and society, and was consolidated, above all, by the studies of Callon (1986) and Latour (1987).

Latour (2006) says that the researcher develops experiences from his research object, using several tools for the construction of knowledge. This statement represents, briefly, the guiding process of this research.

This author also affirms that technologies are not only artifacts, they are networks of people and things and if you take technology from the network, it no longer has meaning, it needs to be interconnected with environments and with people. The interaction takes place, basically, through human interactions, but what made the human do, that is, act from an external element, is the object, according to Latour (2006) has its own historicity.

Latour (2006) presents and expands the principle of symmetry - the same examples of causes explain true and false beliefs - allowing all groups to simultaneously and symmetrically construct their natural and social reality.

The actor-network theory emphatically brings the idea that humans and nonhumans are linked to a social network of elements. Human and nonhuman actors act mutually, interfere, and influence one another's behavior, with the difference that the human can adjust the non-human element according to their need.

Therefore, in the concept of symmetry, human and non-human actors help each other to develop a new situation. These actants have the same power in the relation, none are superior or inferior to the other and establish a systemic and complex set of interactions among themselves.

Systems Dynamics – from conceptualization to modeling

The Club of Rome, which aims to study and understand the dilemmas of mankind by proposing resolution solutions, during the global crisis of 1970 invited Jay W. Forrester, information professional and engineer, to develop an analysis of the situation of society. Many of the problems encountered are faced to date and have resulted from short-term measures taken in previous decades (Forrester, 1995).

Forrester (1961) published the book, Industrial Dynamics that focused on the dynamics of industries. This author affirmed that the advancement in management was in the understanding of how success interacts among the various flows of information. With the scope of the Industrial Dynamics and its use in other areas, besides the industrial, the concepts were denominated Dynamic Systems.

The challenge of Forrester (1995), with the invitation of the Club of Rome, was to guide the transition from growth to equilibrium. In his book Contradictory Behavior of Social Systems, Forrester (1995) says that one must choose and work toward a desirable kind of equilibrium before reaching the point where the system imposes its own choice of unfortunate consequences.

The Systems and their Concepts

It is necessary to present here the concepts referring to Systems, Dynamical Systems and Complex Systems.

Bertalanffy elaborated in the 1950s the General Theory of Systems. Based on these studies, he conceptualized Systems as the set of elements that have a relation and form a unit to reach a goal (Bertalanffy, 1975; Alvarez, 1990; Oliveira, 2002). The result of a given system is always greater than the result of the action of the elements that compose it (Alvarez, 1990).

Garcia (2014) says that a system is like an object endowed with complexity, formed by coordinated elements, so that the set has a certain unity, these elements interact with each other and continually affect themselves to achieve the purpose for which it was conceived.

A system is composed of Input: capture and gathering of elements that enter the system to be processed; by the Process that transforms or converts the element that has entered and by the Output, the final product that has gone through the process of transformation (Garcia, 2014).

According to Aracil (1997) Systems are defined as an objects endowed with complexity, composed of coordinated parts that form a unit. These systems are used to study an aspect of reality, the different elements that form it and also, as happens to the integration of these elements in the analyzed unit. The parts that form them and the relationships between them can be clearly defined (Aracil, 1997).

The Dynamic Systems approach is conceptual, to understand how the behavior of a complex system develops in a given time. Understanding dynamics is understanding how changes happen in the system.

Dynamic systems are used as a methodology to understand how complex systems are developed. These systems are composed of several principles that interact in different proportions, as in Alvarez's (1990, p.16) statement:

> [Dynamic] system can be defined as a set of interdependent elements that interact with common goals forming a whole, and where each of the component elements behaves, in turn, as a system whose result is greater than the result that the units could have worked independently. Any set of parts joined together can be considered a system, provided that the relations between the parts and the behavior of the whole are the focus of attention.

Complex Systems have a large number of elements interacting with each other, presenting an increasing, non-common and self-organized performance. It is understood as increasing performance, or emergent properties, the interaction of elements on a large scale that may cause strangeness and is difficult to diagnose even in the case of simple interactions. (Mitchell, 2009).

Aracil (1997) describes that there is a proper language to perform the description of a system, its structure and behavior. It is called this 'model' process and means representing an aspect of reality.

Modeling Processes

The modeling process consists of a set of operations, before which study and analysis are required to construct the model of a real problem.

In this process the following phases are performed:

a) Definition of the problem: adequacy and magnitudes and variations over time that one wants to study.

b) Conceptualization of the system: adequacy of the systemic language and definition of the elements that integrate the description;

c) Formalization: conversion into influence diagram and description of functions;

d) Behavior of the model: simulation with software to verify the trajectories;

e) Evolution of the model: The model is submitted to several tests and analyzes to verify its validity and quality;

f) Exploring the model: The model is used to analyze alternative policies.

For the construction of a model, one starts with numerical records of the trajectories of the quantities and how they produce the interactions within the system. An important step in this process is to perform the Sensitivity Analysis, which will demonstrate how possible variations in value, parameters and functional relationships affect the conclusions of a model.

For Bardach (2006) the structure of the systems is constituted by constitutive elements, norms that govern the interactions and information necessary to the system for the applicability of the rules; which results in positive or negative feedback cycles.

Positive feedbacks are said to be more interesting because they are complex and counterintuitive since they are in all growth and development processes. From these feedbacks, the above-mentioned author presents seven elements:

Momentum - is the influence of the context in the interaction, at that exact moment, which at another time will not have the same result and / or reach;

a) Selective retention, or a competitive process;

b) Dependent trajectory - the actions of the past influence the present;

c) Learning and experimental error - is the process of solving problems of trial and error;

d) Complex systems - have some difficulty in predicting;

e) Theory of chaos - may not present a pattern and the answers are random. It is emphasized here that these models can only be applied to substantially closed systems with a relatively long history;

f) Sequencing - Each interaction feedbacks the system and a new state appears.

Negative feedback cycles have two forms, one that oscillates within a certain limit; and another of efforts to maintain a monopolistic equilibrium (based on superior political power). Bardach (2006) points out that when reformers can succeed, this is classified as an unbalancing process. For him, successful policies can lead to the creation of new problems, that is, when a policy is successful, its costs are greatly increased, and from there the system can become unpredictable.

The models are not structured in isolation, they are dynamic processes that are inserted in the organization and / or in the social context. Therefore, the model gives feedback that allows change, questioning, refinement to lead to the elaboration of

new strategies and decision rules. As a modeling process, Sterman (2000) recommends:

a) articulate the problem to be solved

b) formulate hypothesis, dynamics or theory about the causes of the problem

c) formulate a simulation model to test the dynamic hypothesis

d) Test the model until it satisfies its purpose

e) design and evaluate improvement policies.

Finally, subsequent to the construction of hypothesis dynamics, Sterman (2000) suggests steps of formulating a simulation model, that is, virtual tests, with the use of data related to reality.

Therefore, for Bardach (2009), the system has a dynamic and can undergo modifications that will impact the entire system, modifying it. The use of dynamic systems can aid in the analysis of various situations and in decision making.

METHODOLOGY

The methodology used was the one of bibliographical research as an objective to broaden the understanding in relation to the subjects approached as actor-network theory, knowledge in the light of the dynamics of systems and agent-based modeling. This type of research provides "familiarity with the problem in question" (Gil, 2010, 27, Marconi and Lakatos, 1996). The chosen bibliographic delimitation provides the knowledge of the content already researched (Gil, 2010).

Based on the above statement, we chose to observe a group of women from the region of Guaraqueçaba who, after participating in some workshops, had the objective of discussing cross-cutting themes for citizenship education, such as raising self-esteem, health, women's rights, work and income, sustainable behavior, production and transformation of agroecological foods, promoting productive inclusion, the rescue, the strengthening of local culture and the full exercise of citizenship.

Therefore, this research is based on a non-probabilistic and intentional sample, since the researcher started from the specific characteristics of this particular group, according to Sampieri, (1991). The researcher's knowledge about the context, since there is a larger research project, whose characteristics are the processes of knowledge construction, guided the choice. Thus, using actor-network theory, it will be possible to map networks of human and nonhuman actors seeking to prove that, and how, knowledge is made through interactions.

The workshops, conducted by research professors, have made the women's group more aware of who they are and what roles they play in the fishing community. Through some issues addressed such as women's rights, equality and professionalism, they began to engage in existing community programs, hitherto specifically for men, they began to see themselves as fishing professionals in one dimension of their work that they did not see, since they participate and carry out activities very specific, but that until then, these women, they saw only as housewives. It was then that the theme to be studied was defined: the process of creation of the knowledge of a collective of women of Guaraqueçaba - PR, with its increase or decrease.

In order to make possible the representation of this model, we used Vensim, a simulation software developed by Ventana Systems that performs continuous simulation (dynamic systems) and has modeling capabilities based on agents. It is available commercially and also with a free personal learning edition (Ventana Systems, Inc. Marketing Templates).

An initial survey was carried out to verify the scientific production in this field, investigating the novelty of the theme. The Capes Portal was used as a search platform, which has a significant collection; in this search we opted for the following descriptors or keywords:

Table 1: Bibliographic survey.

DESCRIPTOR	NUMBER OF ARTICLES
Dynamic systems + Knowledge representation + Women	01
Dynamic systems AND Knowledge representation AND women group	18958
Knowledge representation	741.644
Knowledge representation' + Vensim + Women group	20
Knowledge representation + Vensim Simulation	262
Knowledge representation' AND Vensim AND Women group	19
Women fishing in Guaraqueçaba	03
Women fishing + Vensim	02

Source: The authors (2017)

From this survey, it is observed that there is little research related to women fishers and even less when searching for this descriptor allied to knowledge representation and Vensim Software, considering the technology issue, addressed by Latour (2006). The article in the table reports on the increase in salmon fishing in Norway, with jobs being expanded for women, and software simulation is carried out in relation to capacity building, motivation and conflict inhibition, but not for generating knowledge.

Based on these data it is inferred that the researches regarding the subject proposed in this article are still incipient, configuring itself as a singular and interesting theme of research, mainly related to the issue of social insertion policies.

STUDY DEVELOPMENT

Based on the studied simulation process, in the definitions about knowledge, networks and dynamic systems, we wanted to study a complex system. The objective is how to represent the variation of knowledge generated in a collective represented by women fishers, through dynamic systems. The public of the fishing women, whose territory belongs to Guaraqueçaba in the State of Paraná (Brazil), was defined intentionally, as already mentioned.

It can be said that this group of women fishers form a complex system, since they interact with each other, with the teachers of an educational institution that monthly develop workshops with cross-cutting themes for citizen education such as elevated self-esteem, health, women's rights, work and income. In addition, some of these women represent the group and attend meetings with teachers, state government agencies and when they return, they pass the content on to the group so that all decisions are taken together. There are also interactions with people who do not participate in these events, but who are family members who bring their knowledge and give their opinions. This relationship is called "word of mouth." In all these moments there is the exchange of information and the creation of environments favorable to the construction of knowledge.

The model settings are:

a) Identify and present a dynamic model to represent the increase of knowledge through specific actions such as:
   - Workshops - 10 people
   - Meetings - 5 people
   - Word of mouth - 2 people

b) For negative feedbacks included a forgetting rate and also, to simulate the decrease of knowledge, one death per year.

c) To start the system, the following data has been defined:
   - Time step = 1
   - Initial time = 0
   - Final time = 10

After the Vensim software application, the diagram shown in Figure 1 was obtained from the data above. The Multiplication WOW (Word-of-mouth), Multiplication MWL (meeting with leaders) and Multiplication LW (lectures and workshops) are indicators inserted in the software to see how the system will work from them and what graphics it will display.

To carry out this simulation, some values were intentionally defined as can be verified:

a) Knowledge = 1 number of people possessing knowledge, is the sum of Meetings with Leaders, Lectures and Workshops, Mouth to Mouth, minus Oblivion (initial value = 1);

b) Forgetfulness = multiplies by an exponential equation, because the greater the time, or the age of a person, the greater the degree of forgetfulness.

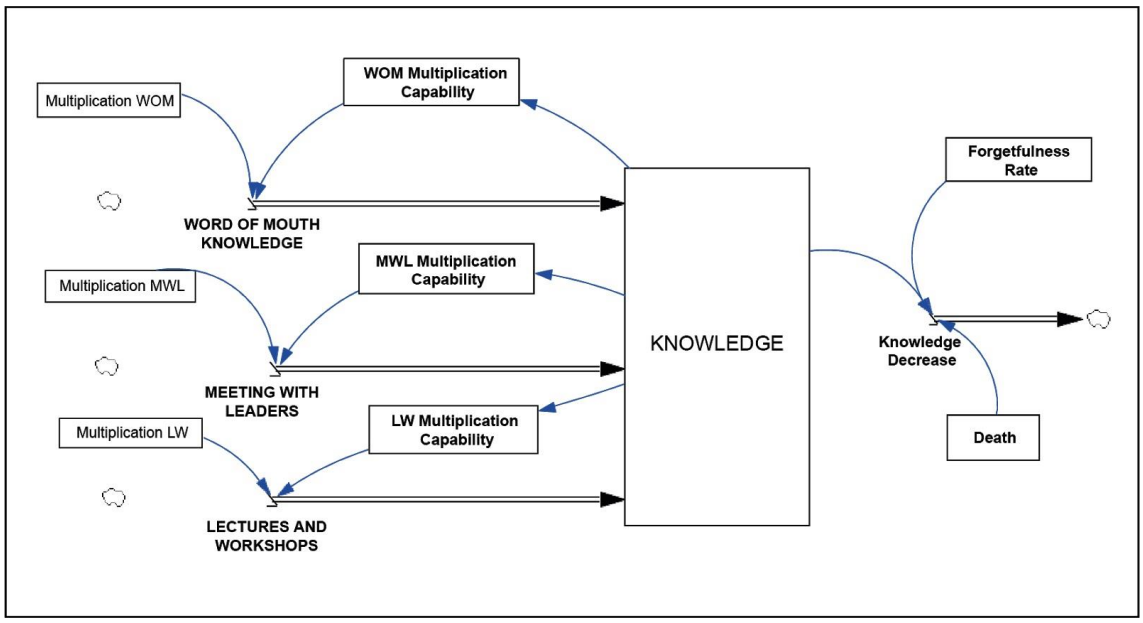
c) Word of Mouth = A person holds a certain knowledge, which can multiply it. In this case, a person multiplies his knowledge to a person;

d) Meetings with Leaders = Only 10% of people who have knowledge multiply it in meetings. It was defined 5 people per meeting;

e) Lectures and workshops = Only 5% of the people who have the knowledge can multiply it in lectures. Twenty people were defined per lecture.

f) Death = To demonstrate that knowledge can decrease, it was stipulated here the death of 2 people per year.

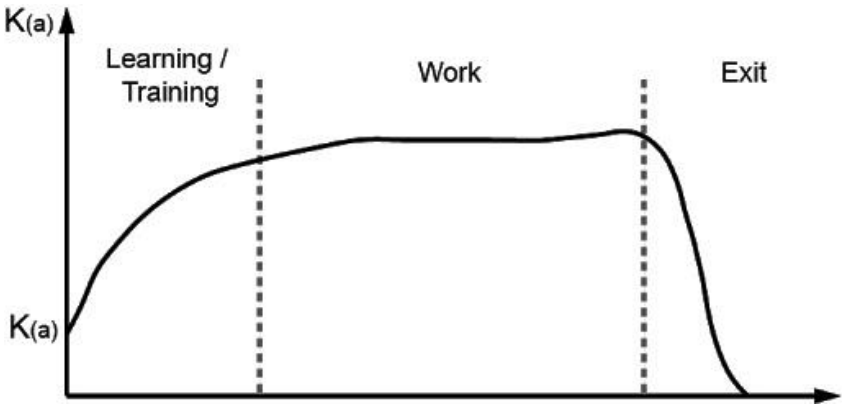
Figure 1: Representation of the increase of knowledge through Vensim software.



Source: The authors (2017)

It was believed that with the departure of a component, or by not using a certain practice, there would be an abrupt decrease in the level of knowledge, contradicting the learning curve and the notes of Strauhs, Abreu and Renaux (2000), who stated that activities of insertion into groups has an initial period of great increase of knowledge (learning period or training), which stabilizes with time (work) and decreases with the output of members (output).

Figure 2 - Learning Curve



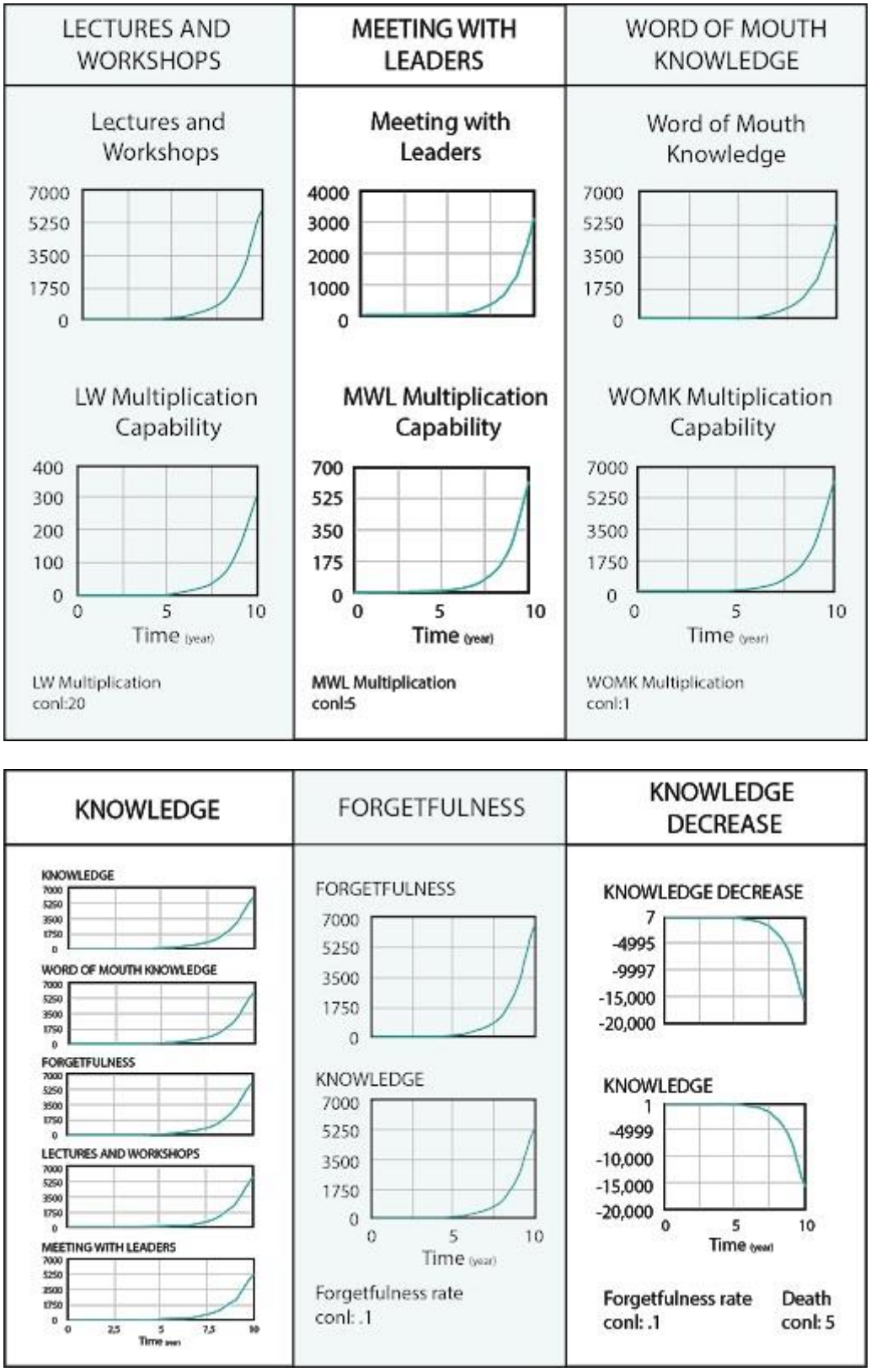
Source: Adapted from Strauhs, Abreu, Renaux (2000)

When performing the simulations using the elements described previously, it is noticed that when there is interaction through meetings, word-of-mouth or workshops, there is a result in which knowledge tends to infinity because it is a positive loop in which there is only growth.

It was then defined to include situations that could represent the decrease of collective knowledge, then included the rate of forgetting and death. It is observed in

the graphs that these factors cause a fall in the knowledge stock, but it does not change significantly the growth curve.

Figure 3: Representation using graphs



Source: The authors (2017)

ANALYSIS AND INFERENCES

It was noticed that there was a positive influence in the group of women after some meetings and discussions regarding the themes already mentioned, they perceived themselves as protagonists of a knowledge process and the more they knew and shared a certain subject, the more they reworked and modified the way they see the world or a certain subject, even modify their relationship with the artifacts of their daily lives, take the boat to the water, fish food with the different types of nets, collect crabs. They perceive themselves as actants, indeed fishers!

Latour (2012) is then reaffirmed, when he says that knowledge is fundamentally of the human being, but artifacts created from knowledge, which are nonhumans, have a history. These artifacts, according to Latour (2012), appear not as complete actors, but incorporated into daily life, suffering the interference of society and power and also intervening in them. For him knowledge comes from the perception of the world, through experiences and objects have a history, independent of the relationships, associations or interpretations made by individuals. He affirms that everything is in experience and every step of knowledge is the fruit of this experience. "There is more to experience than meets the eye." (LATOUR, 2012, p.160).

Therefore, the role of artifacts in the creation of knowledge is fundamental, because when these women develop their perception of the world, they create a new knowledge or rework the previous knowledge. From there, they are able to influence, enhance and even create new artifacts, including other technologies and other ways to improve their day to day lives.

It can be said that there is an empowerment on the part of these women in the future work and that these situations between the human and nonhuman actors corroborates the concept of symmetry of Bruno Latour.

FINAL CONSIDERATIONS

The database proposed in this article comes from the experience of one of the authors with these women from Guaraqueçaba and from the joint research in the field of Knowledge Management and Public Policies in a Brazilian Postgraduate Program.

The result of the data simulation points out that knowledge will always increase in a model of continuous flow of growth, even if there is a part of forgetting this knowledge by the people or even with the death of one of the members. This decrease in knowledge is little perceived since the increase made through lectures and workshops, meetings and word of mouth, in the specific context, has made this increase on a large scale. It was not studied how collective knowledge behaves when a member leaves the group spontaneously, inferring that this case is attended to by the question "death", contrary to the expectation of abrupt decrease of the knowledge of the collective, according to the initial assumption. These observations are not, however, conclusive, point to the need for further study.

From these scenarios it can be seen that the involvement of women in these activities is a central question to assume that there is effective and non-ephemeral construction and generation of real social advancement. From this analysis, it can be affirmed that with the generation of effective knowledge these women can influence the non-human actors contributing to the improvement of the quality of life.

It is observed that in a dialogical context, called by Nonaka of 'Ba' in which there is information, occurs the perception and apprehension of a knowledge that shared can become the knowledge of a group and the sum of the knowledge of all the members is the intellectual capital of the group researched in this work. (POLANYI, 1966, NONOKE ET AL., 1997, DRUCKER 2002 AND STEWART 1998).

Research in this area may serve as a tool for dynamic systems to subsidize the construction of public policies or government programs that would allow the participation of these collectives in programs that today do not have access, due to their low level of education and the place where they live.

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