Modeling for Learning Organizations and Qualitative Reasoning: Grounding a Case Study within IT Management

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Abstract

Starting from the foundations of the so-called Second Generation Knowledge Management (SGKM), in this paper, we identify what we think to be a suitable synergy between two approaches firstly considered in two different fields, namely, System Dynamics and Artificial Intelligence. The emphasis of SGKM on knowledge creation, increasing attention seems to be needed for Organizational Learning. Under that light, and in order to draw our assumptions, we recall a number of features from the two approaches from Management and Computer Science, namely, their concerns with modeling processes. Our mid-term goal is to prepare a case study on a working team on IT Management recently organized in a bank in Brazil. One challenge for this team is to ensure consistence among the different solutions for different IT areas in the bank. Our first assumption is that these approaches are implicitly present in the very nature of the team’s work. Secondly, we think that bringing the approach to an explicit level, would increase the team performance toward its mission.

1 Introduction

In his recent reflections on KM [McElroy, 2003], Mark McElroy advocates in favor of a different view of the field which is born to overcome the so-called First-Generation KM (FGKM) and its “technology-centric brand of thinking”. The author states that this Second-Generation KM (SGKM) is more inclusive of human resource and process initiatives. Moreover, SGKM is founded on a number of new concepts falling into eight categories, namely, (i) Supply-Side vs. Demand-Side KM, (ii) The Knowledge Life Cycle, (iii) Knowledge Processes, (iv) Knowledge as Rules, (v) Knowledge Structures, (vi) Nested Knowledge Domains, (vii) Organizational Learning, and (viii) Complexity Theory.

With respect to (i), the advocated slight difference between the two KM generations comes up under the form of an emphasis on distribution of existing knowledge - the Supply-side - vs. its dual emphasis on knowledge creation - the Demand-side. Yet for McElroy, Supply-side KM initiatives often recall classical IT-based solutions for knowledge sharing while Demand-side ones focus on promoting innovation and creativity. Increasing competitiveness by helping organizations to create new knowledge faster is then the emphasis of SGKM, the big-deal being high-performance learning. Such a scenario leads the author to point out a convergence between Knowledge Management and Organizational Learning (OL).

From our perspective, what the author’s positioning should bring to those who are holding the cause of making technology in synergy with knowledge management, is the challenge of re-thinking the way of doing so, such as to embed SGKM pillars onto their projects.

As a matter of fact, the SGKM topic of Learning Organizations have been attracted the attention of scholars eventually with different research foci, but already sharing the challenge of promoting learning within organizations by means of technology (e.g. [Abel et al., 2004; Ikeda et al., 2002]). Concerning our own engagement with such a challenge, the first efforts within our teams towards the context of (SG)KM have led us to a model of asynchronous collaborative work, where the users interact aiming to reach a common language [de Castro et al., 2004b]: learning in individuals is expected to be a side effect of this social process, considered as such. In a given time, the language under construction is seen as a model representing the group consensus at that time.

As carefully looking at different contexts than someone’s “own(s)” is often inspiring when working with scientific disciplines, it seems for us that LO would benefit from other fields that have been successfully merging learning with technology, particularly with Artificial Intelligence (AI), for instance, let us mention the communities named Intelligent Tutoring Systems (ITS) and Artificial Intelligence in Education (AIED). We believe our first efforts toward LO are strongly influenced by our (short?) history within those communities (including [de Castro et al., 2004a; da Nóbrega et al., 2003; 2002]). On the other hand, let us register our awareness that special attention should be given when considering learning within the context of organizations, as the KM & OM community have been doing: one should have in mind issues like innovation and competitiveness while trying to instigate creativity within organizations.

Under the light of our first conceptual results, reported in [de Castro et al., 2004b], one of our current interests - relying on constructivists theories - is the one of investigating model-
oriented techniques/methodologies suitable to support (end-)users during a modeling process. As we highlight further in the paper, one of the pillars sustaining the assumption we are bringing is the amount of relevant work involving educational purposes and model-oriented approaches (within the above mentioned ITS and AIED contexts).

Within the widespread field of Computer Science, the modeling task is often concerned with the construction of artifacts as abstractions during software life-cycle: it aims at understanding the reality being modeled, communicating with customers for validation purposes, facilitating maintenance, among others. In such a context, research questions usually address the development of methodologies and representing languages in order to support those tasks. Particularly, within AI and the so-called Knowledge Engineering - and more recently Ontology Engineering when concerned with domain ontologies - the modeling task is often tied-up with knowledge and expertise. However, when meeting the KM community, AI researchers with modeling concerns are faced with the challenge of accounting to knowledge modeling far beyond a content perspective. As stated above, we believe that initiatives in this direction are invited to plunge deep inside organizational contexts assigned nowadays to competitiveness needs, as the KM & OM community has been doing [Bekhti and Matta, 2003; Chen-Burger et al., 2002].

In this paper we identify what we think to be a suitable synergy between two approaches from two different fields, namely, System Dynamics and Artificial Intelligence. Also we argue in favor of the benefits we suppose that marriage could bring to KM, and to LO in particular. We accomplish such a task along a two-step rationale: (i) in §2, we highlight the features that have attracted our attention within both the Modeling for Learning Organizations perspective (from System Dynamics), and the Qualitative Reasoning perspective (from AI), our interest on those features being to be able of pointing out to a promising marriage for KM; (ii) in §3, we describe - from a real organization - the mission of a team working on the context of IT Management; that should play for us the role of empirical evidence confirming our assumption, as long as the team performance could be increased from embedding both the MLO and QR perspectives into its grounding working directives. Finally, in §4, we recall our objectives in the paper, such as to position them with respect to our ongoing work.

2 System Dynamics and Artificial Intelligence: a promising marriage to handling models for (SG)KM?

In this section we introduce the two main approaches on which we are grounding our study, namely, (i) Modeling for Learning Organizations (MLO) and (ii) Qualitative Reasoning (QR). As these two approaches find their origins in two different research fields, respectively, System Dynamics and Artificial Intelligence, in spite of highlighting the features we find relevant for our purposes, our goal is to bring to the KM & OM community a discussion on how these fields might synergistically be joined such as to benefit (SG)KM.

2.1 Modeling for Learning Organizations

According to the System Dynamics Society, “System dynamics is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems”. The main feature allowing to distinguish the scope of study of System Dynamics from other approaches is the feedback referring to mutual influence - directly or through a chain - between entities in a system.

At MIT Sloan School of Management, the “System Dynamics Group” was founded in the early 1960s by Jay W. Forrester, the one who has launched the field. In order to support the study of complex systems, the (non-linear) methodology includes a number of steps, ranging from identifying a problem up to implementing a solution, and passing by computer simulation of a model built accordingly.

The increasing interest on System Dynamics approach over the last four decades is evidenced by the grown of application areas having exploited it. These include: corporate planning and policy design, public management and policy, biological and medical modeling, energy and the environment, the theory development in the natural and social sciences, dynamic decision making, complex nonlinear dynamics. The System Dynamics society involves members of fifty-five countries around the world, and it is responsible for a number of activities including organizing an annual conference on the subject and a quarterly journal.

From a System Dynamics series (Productivity Press), the book Modeling for Learning Organizations [Morecroft and Sterman, 1994] is dedicated to the specific topic of learning in organizations by means of building models. According to the Publishers’ perspective [Bodek and Asay, 1994], when presenting the book, Peter Senge’s “The Fifth Discipline” book [Senge, 2002] introduces basic concepts of thinking as well as describes a valuable role for System Dynamics in managing organizations, but, by means of the MLO book, Morecroft and Sterman bring answers to important questions that readers of Senge’s book have in mind, ranging from “Where do I go from here?” up to “How can I survive the short-term pressures to initiate policies with long-term positive outcomes?”

One of the relevant questions we highlight from the MLO scholars concerns the goals of modeling within organizational contexts [de Geus, 1994]. Trial and error seems to offer for humans a high-quality (although time-spender) learning mechanism (also borrowed by certain AI formalisms). Building models provide an interesting practice for experimenting with representations of the reality one deals with. However, in certain situations, and particularly concerning management, errors are often prohibitive due to its high-cost consequences. Being thus, one important question to be asked at this point would be how actually useful the modeling practice could be within organizational context, where it seems to have no place for errors. The answer seems to recall learning within organizations foundations: rather than directly (and on-the-fly) interving on the realities around them, managers
could benefit from building models by acquiring experience from simulated situations, as they do their minds accordingly. As stated by Morecroft [Morecroft, 1994], “learning takes place when people discover for themselves contradictions between observed behavior and their perceptions of how the ‘world’ should operate. Moreover, the Microworlds approach, usually familiar to AI scholars, as well as to AI and Education ones, appears as being significant to support learning in managerial context.

In addition to its confirmed value to OL - as attested by the variety of case studies reported in the MLO book - the modeling process within the System Dynamics perspective would have yet further contributions concerning simulation, as we point out below.

2.2 Qualitative Reasoning
According to the organizers of the “18th International Workshop on Qualitative Reasoning”, “Qualitative Reasoning is an exciting research area at the interface between Cognitive Science and Artificial Intelligence...”. The Qualitative Reasoning (QR) area is born in the early eighties, and researchers have been meeting around the theme at the QR Workshop series since 1987. QR intends to formalizing the intuitive knowledge of the physical world, from person on the street to expert scientists and engineers by developing reasoning methods that use such knowledge for interesting tasks and developing computational models of human commonsense reasoning. QR Scholars claim that qualitative approach provides natural level of detail, allows for partial knowledge and express intuition of casualty.

In the late eighties there was a rapid expansion when appear the first applications: qualitative process automation, and MITA photocopier. In the nineties QR reach its maturity with lots of interesting demonstrations, more fielded applications, many new ideas, model construction from data in material science, medicine, compositional modeling, self-explanatory simulators and large-scale textbook problem solving. From 2000 until now QR has experimented new directions: material Science, cognitive science, biology, ecology and others.

QR Workshops series bring a variety of work on theories and experiments concerning human reasoning and learning of mental models, QR techniques and other modeling approaches. Similar interest exists for ITS/AIED/ICALT communities that discuss the use of Model-Based Systems and Qualitative Reasoning for Education [Harrer et al., 2004], and given the empirically attested relevance of MBS/QR for learning systems [van Joolingen, 2004], as well as with particular emphasis on collaborative work [Salles and Bredeweg, 2003; Ureel and Carney, 2003]. MBS/QR appears to be appropriate for the implementation of major function of intelligent training, help and teaching environments, such as (model-based) diagnosis of learner behavior and explanation. In addition, by considering knowledge construction as an important aspect of learning, one also finds MBS/QR application in learning by building qualitative simulations. In our opinion, this latter could have much to offer to Organizational Learning, at least considering SGKM and its focus on (collective) knowledge construction.

As an attempt to summarize the main features within the approach, let us state that QR is an area from AI that deals with representations for world aspects in order to support reasoning with little information, as mentioned above. Typically, it was focused in the scientific and engineering domains, this being the reason why is also called Qualitative Physics. Its motivations are mainly coming from two observations:

- people reach useful and non-apparent conclusions about the world without using differential equations. In our every day life, we know what is happening around us and how we can interact working with scarce and inaccurate data. Working with less than would be necessary for the utilization of quantitative methods. Creating robots that operate in an uncontrolled environment and modeling cognitive human processes require understanding of how this can be done;
- Scientists and engineers apparently use qualitative reasoning when seeking the initial understanding of a problem, when they chose which formal methods they should use to solve particular problems and when they interpret the results of quantitative simulations, calculations and measurements.

Research in QR has developed theories, representations, and reasoning techniques that enable one to deal with systems characterized by lack of explicit or complete information. Qualitative modeling provides formalisms for expressing intuitive, causal models and the reasoning techniques needed to generate predictions and explanations for helping users to find out the consequences of their ideas.

Despite the fact that qualitative reasoning is apparently associated with the area of Physics, its application in other domains such as Economics or Ecology is present. However, according to a study carried out by [Kamps and Peli, 1995], the application of qualitative reasoning in Physics is different from its application in others domains. The difference, according to the authors, seems to emerge from the very nature of the domains. Other sciences, such as Economics, are less understandable, less formalized, in other words, they need a deeper understanding of their functioning than does the area of Physics. A first consequence in building models in these areas is that they demand more effort, are more time consuming. However, the value of the simulation process remains.

In a relevant work presented a few years ago to the QR community, Neil Smith [Smith, 2000] addresses the question of providing the so-called “qualitative system dynamics” with additional formalism such as to allow more precise analysis without the needing of obtaining quantitative correspondence. Smith proposes an augmentation on influence diagrams, as a first step towards formalization since Peter Senge had addressed the qualitative system dynamics issue, with however “no formal basis”, as stated by Smith in his paper.

Recently, an excellence network named MONET (European Network of Excellence on Model-Based Systems and Qualitative Reasoning) was born and is today responsible for a number of task groups (including on education and training) aiming at advances in the QR/MBS area, as well as organizing the main discussion meetings around the theme.
3 Towards a Case Study within IT Management

In this section we describe a working team on IT Management recently organized in a Bank in Brazil (to which we will refer as to B Bank). After inspecting the literature within both System Dynamics, and particularly Modeling for Learning Organizations, as well as the one of Qualitative Reasoning, the first assumption being drawn here is that these approaches are implicitly present in the very nature of the team’s work. Secondly, we think that bringing the approach to an explicit level, would increase the team performance toward its mission. In what follows, we invite the reader to follow a description of the team, along with an illustrative scenario of reasoning within IT architectures. The second assumption - and the additional effort needed to accomplish its consequences - is subject of further investigation.

3.1 The Architecture Team from B Bank and its Challenging Mission

In 2003, an architecture team was created to manage the technology area of B Bank. As a general motivation for the creation of the team, appear the lack of consistence among the different solutions for different areas. Before that, each group used to adopt a solution that looked the best one from its viewpoint. After a while, the need for integration, the changes in business, the growth of the company, etc., often demanded technical changes. These changes were generally hard to accomplish in most of the times.

The architecture team was inspired firstly to become the IT area of B Bank under an organizational learning perspective. As stated early in the paper, a learning organization is one where people are improving their skills continuously in order to create desired results, to rethink patterns all the time and to continuously learn how to learn together. The architecture team proposal was also to reach these goals. It is composed of people in the top of their experts careers and they have excellence in one or more technology areas. These architects care about align business and technology, as well as in building conceptual, logic and physical maps to describe the adopted solutions. By using these maps, the architects think to create a good environment to use and to disseminate architectures, and to create mental models to facilitate implementation of desired policies.

The group was then charged to unify technical visions and to look at short-term future as well as long-term future. This is because there are many people involved and the changes take too much time before being totally accomplished.

Currently, the team counts on two meetings in a week. These meetings are called sessions and they are of three types: collaborative, ordinary and deliberative. During these sessions, the team discusses about proposed models, constructed by architects. Also, they invite other people somehow involved in the matter. There is one representative architect for each matter, who is charged to get documentation, make proposals and also for involving people. The collaborative sessions collect opinions and different views, and the ordinary sessions have a well-defined proposal taken by the representative architect. During the ordinary session, it is possible to disagree with the proposal and to present a counter-proposal. In the deliberative session, the representative architect submit the proposal to an election, and only architects have the right of voting.

The architecture team is bringing to the B Bank a comprehensive vision of the bank systems’ and dynamics’. Today, it is possible to notice the interaction and dependence among architecture domains. and soon it should become possible that changes and new investments can be analyzed in advance, allowing to measure the possible impacts in different domains. In a short time, it should also be possible to see if the actions for adjusting or for technology innovation are aligned with the enterprise business perspectives.

3.2 A Modeling Scenario

Figure 1 illustrates a component in a storage management system. This component is charged of storing files written by user applications in cartridge. There is a software called
Hierarchical Management (HM) that controls the cartridge, writing and reading, as well as to keep free space between cartridges and to records the retention time. "Retention time" accounts for time when a file is to be deleted.

After a cartridge is written it is labeled with a number. This number is associated to a file. When an application asks for a file, the software mounts the cartridge with the number assigned to the file.

Each cartridge stores 80 GB of data. In order to save space, the software writes more than one file by cartridge. Further, to improve the response time of the applications, the software writes the file in a direct device (DASD) and later it writes many files in a cartridge. This first step is called migration level 1 (ML1) and the second migration level 2 (ML2).

After a while, due to file deletion process, some cartridges may have many “holes” - empty spaces among files recorded.
When this is detected, the software performs a read in a cartridge containing “holes” and writes files to another cartridge in order to save space. Cartridges are kept in slots. Thus, in order to read or write a cartridge, it is necessary to move a cartridge to a drive.

The response of the system is determined by the amount of data written and by the amount of slots, drivers, DASD and cartridge. We can consider that the size of the cartridge and the machine reading, writing and mounting speeds are constant.

Although we think it is possible to use QR in strategic situations, this simple example inspires us the use QR for IT management support. On the one hand, this particular example is operational but, on the other hand, we think it is useful to illustrate applying Qualitative Reasoning to IT management, since it shows us the possibility to simulate many variations of quantity of resources and of amount of data, aiming at optimizing the overall process by identifying eventual bottlenecks. Figure 2 brings a diagram illustrating a possible behavior of the system. The diagram shows that without a control, the waiting time for applications may increase significantly causing abnormal ends. The amount requests that applications make for writing or reading a file in a cartridge vary day-by-day and it is not possible to accurately predict that. Those requests are influencing other variables such as the amount of cartridges in slots and drivers, which is also influenced by recycle and retention time. Within the scenario, one need is to estimate roughly the number of cartridges in slots and drivers to render available in a period of time - a semester or two for instance - such as to improve the system response time and having a better schedule of purchases and deployments.

4 Conclusion

In this paper, we bring the discussion on explicitly merging two approaches firstly considered in two different fields: System Dynamics and Modeling for Learning Organizations in particular, from Management and Qualitative Reasoning from Artificial Intelligence. Our goal is to build a conceptual ground allowing us to prepare a solid theoretical basis in order to draw, in a close future, a case study within IT Management, with an architecture team.

The architecture team has a challenge in changing the technological area of the bank in order to offer to managers a shared view on systems thinking. Modeling for learning in individuals as a consequence of social processes with learning purposes - either synchronous or asynchronous - seems to go in the direction of the so-called SGKM and its knowledge creation perspective (on the basis of Organizational Learning). The mainstream System Dynamics seems to offer an interesting feature to be inherited as a moving engine to actually promote learning: modeling and (computer-)simulating systems’ behavior such as to allow reasoning over mutual influence between entities. In addition, QR (and AI) could be of great aid as long as a system is able to reason on models being built such as to become a rational assistant during the modeling process. We see these techniques as appropriated for complex systems non-quantitative and with many variables.

A description of the team, along with a scenario with a possible system to be modeled is presented in the paper. This scenario could come together with others more or less strategic depending on the matter to be modeled. Our understanding concerning the possibility to model within management of an IT area includes thus both operational and strategic matters.

Since the case study we are about to prepare seems significant given the relevance of the concerned organization, it would be important for us, before going further, to hear from the KM & OM community their impressions according to their major experience within the domain. At the same time, we hope that the discussion presented and/or the effort needed to actually get empirical results from the case study can somehow contribute to the field.

References


