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Scientific Knowledge Management Anchored on Socio-environmental Systems

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Abstract: *In this article we discuss the actual tools used to create and disseminate knowledge among scientists and stakeholders. First we present a structural framework, concerning the co-construction of an interdisciplinary scientific knowledge considering environment as a major variable. Then, a demonstration is presented through two sets of drawings: a first series of drawings focuses on the relationship between Ideosphere and infosphere and gives a formal meaning to this relationship; a second series of drawings expresses the different facets of a social game (single, multi, inter, and trans-Causality; temporality) and ultimately its ability to produce a shared representation in the power game is analyzed. The drawings are progressively loaded with mathematical semantics (logical and categorical) with the purpose to demonstrate that agreements are constructed within a social game when it comes to produce logical representations. The objective of the structural framework, which as a mathematical object is "free of context", is to provide a theoretical foundation with computational efficiency to multidisciplinarity, interdisciplinarity, and transdisciplinarity scientific work*

Keywords: Scientific Knowledge, Knowledge Management, Trandisciplinarity

1. Context of Scientific Activity

Our era is characterized by the exponential growth of scientific knowledge. The number of research groups, international research projects and scientific publications is growing more and more. In principle, we should have all the answers to these challenges. However, there are many examples where the application of "compartmentalized" or standard knowledge, is not enough. There is a consensus that there are problems that defy the traditional linear, deterministic and objective logic based on the Cartesian rationality that advocates decomposition and analytical resolution in a reductionist way. The problems we face today, such as imbalances in society and in the biosphere, are strongly influenced by environment and the interconnected world. As a result of those nonlinear relationships where the parties are totally interdependent, we are faced with a complexity never seen before. It is becoming increasingly necessary to propose a new paradigm capable of dealing with a collective research by scientific communities for concrete solutions to a problem having no solution known with certainty.

In a systemic view, this new paradigm is based on a causal cycle involving the action of all the scientific disciplines, 1) in an individual way when they find their proof and validation, 2) in a multidisciplinary way when they decide what the good signals to describe reality are, 3) in an interdisciplinary way when they use postulates to diagnose plausible behaviors for the system 4) in a transdisciplinary way when they use risky hypotheses to select potential issues.

When contradictions occur, adaptation and evolution modify the degree of risk of the hypotheses and postulates used to reason by each science.

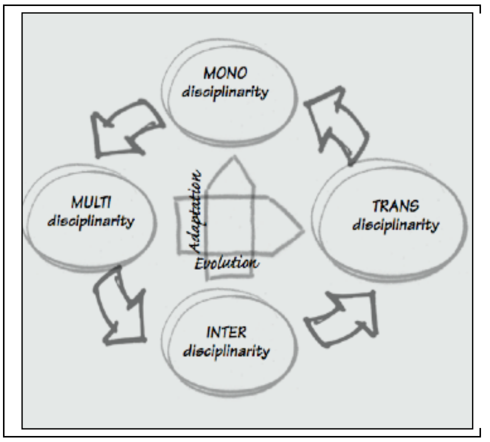

Figure 1: A causal cycle links the scientific activity phases

It seems necessary to develop a new approach in a paradigm that takes into account the systemic view, the complex and transdisciplinary phenomena, and which incorporates in such context Information Technology and Communication (ICT) not only as a specific set of tools and systems, but also as an opportunity to train, orchestrate and connect multiple networks to access and interactive forms and constants. ICT can be the repository of the knowledge built by the scientific community (Figure 2a) or it can manage the social community via impact factor and publication policy (Figure 2b).

We can legitimately examine ICT as a new operating environment for our scientific work as well its cultural and social boundaries. We must also consider how the issues involved in our work force us to think differently in science up to a practice of negotiation between scientific disciplines of the consideration of results proved by other than us in interdisciplinary practice. The complexity theories provide another context of structural framework in the scientific community. Hence the question that will be developed at the end of this section: the efficiency of scientific activity, orchestrated by the ICT and structurally framed so as to combine the activities multidisciplinary, interdisciplinary, and transdisciplinary.

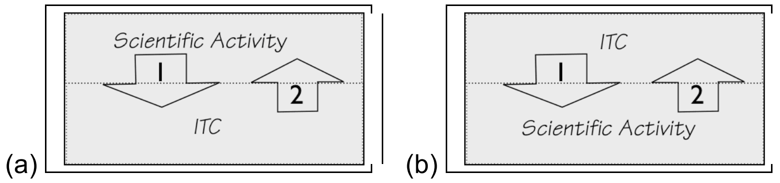

Figure 2: What is prevalent: scientific knowledge or scientific activity?

We propose in this article to better understand the contexts that define a global scientific activity.

2. Scientific Knowledge Management

Let us consider decision making on controversial questions such as “the influence of human activity on climate change” or “how to finance retirement”. Such questions entail controversies between the different stakeholders. The latter initiate debates on the characterization and the definition of the general goals. Their resolution induces the production of norms – laws, pacts, conventions, agreements, practical recommendations – which provide a framework for action at individual and society level.

Nowadays, the way decisions are made by politicians changes. Science sociologists, following Latour (2004), have underlined the end of the former separation between Knowledge and Power, that left the knowledge on nature to scientists, and the organization of society to politicians. Politicians have now to invent solutions to problems on which science fumbles. Sociology itself has progressed: 1) from a sociology devoted to the comprehension of social phenomena such as the reproduction of social classes (Bourdieu & Passeron, 1970), to 2) a sociology of critic (Habermas, 1996; Boltanski & Thévenot, 1991) that deals with the study of functioning modes of a society, in order to achieve 3) a sociology where the practice of norms follows from production of successive agreements (Thévenot, 2009, 2010). The latter considers that the successive stages of norm production by committees in charge of standardization, followed by a period of obedience to these standards and of analysis of the wrongdoing they have provoked, are now at the heart of communication and cooperation modes in our society. This approach is at the crossroads between sociologists and political scientists who adhere to “dysutopia” (Rahnema & Robert, 2008): we are not in an era where new utopias should be proposed, but where the current utopia inhabiting our current world should be used correctly. Such a vision assumes a permanent need of improvement, as any decision-making inevitably entails sacrifice (Dupuy, 2009).

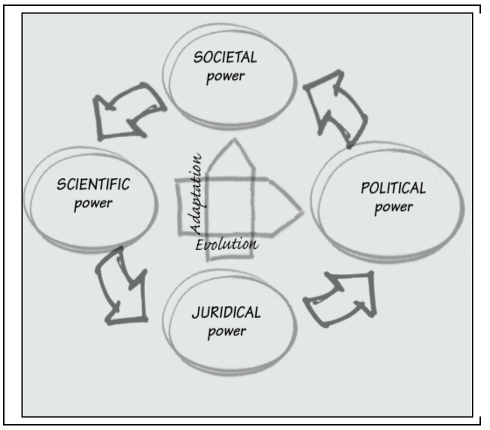

Figure 3: Four powers play in a public debate

The former separation between politics and science is thus overthrown. Power is now divided between four partners: scientists describe the world and build models in order to apprehend it, lawyers legitimate managers who apply standards, politicians detain the authority to impose a choice, and citizens have the ability to respect or not the political authority in place.

The scientific approach used to be encased within a specialized discipline. Now it opens to popular acceptance through an exemplary reflexive approach that takes into account the risk of deceit: risk due both to the intrinsic ill-determination of the problem, and the vagueness of measures and models.

Within the public sphere, the scientist and the politician see how their authority is challenged by citizens who want to participate in the correction of current dysfunctions. This results in a sustained evolutionary and adaptive phenomenon of the regulation systems of the public sphere, that can be observed through a renewed design of standardization processes.

In our current world, a political decision is taken after consideration of numerous simulations that compute the possible consequences for a given model. Thus we face the issue of the impact of a model on a collective decision making. Such an issue is a new form of the epistemic point of view since we were used to a correct correspondence between mathematical models of physics and their capacity of expressing the behavior of physical mater. In human or social science, this is not the case any longer. Indeed models and simulations are used outside the mathematical boundaries that gave initially birth to them and legitimated their use. Let us denote, following Luciano Floridi, the global information processing system by “infosphere”; the Web and the banking industry network are instances of it and their uses impact the public sphere.

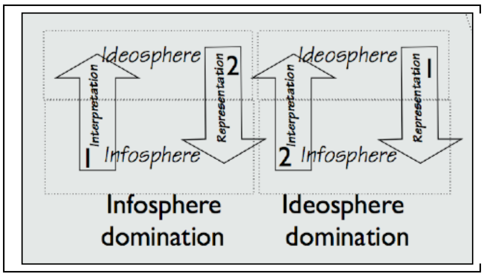

Figure 4: Is *letter* dominating *spirit*?

We have to state the question of the adequacy between the world of computed models that pertain to the infosphere and their consequences on the management of the public sphere: which sphere prevails? Or stated in other words, who adjusts to whom? Are we under the dominance of the infosphere, subordinated to the models used? Or on the contrary, are we currently inventing new governance models that proved a better control of risk factors, uncertainty and correction of unrighteousness due to use of the former models? The world cannot be stopped, but its management fosters thoughts as the previous ones.

It is impossible not to cite the idea of intellectual self-defense defended by Noam Chomsky, discussed by Normand Baillargeon (2005): the inflation and the babelization of knowledge has reached such a level that the only emergency is synthesis, reconnection of notions, development of attitudes and abilities that protect us from being wronged lastingly: an open information, an information open to public debate.

The shift from information scarcity to abundance, or its over-abundance, meets the dual challenge of integrating research and saving time in finding new solutions for problems that are of great social or economic interests.

A first attempt to integrate scientific knowledge supported by ICT has been the creation of Labor Networks in order to achieve more meaningful and consistent work within smaller deadlines: many practices scored below the expected. The difficulty lies in the diversity of working methods in different languages and different ways of thinking about the phenomena studied. Labor Networks also need to consider cultural barriers when they are composed by specialists from different countries and academic environments with differentiated opportunities. Beyond this time of diversity and methodological and epistemological pluralism is a challenge that has not been solved so far. This is the Theory of Complexity, which helps explain the conditions for the union occurring between unity and multiplicity.

A complex system potentially includes many elements which are more or less interdependent and linked together. It also implies the ideas of complexity (different parties together in the same space) and completeness (solidarity). The whole is not the sum of its parts because it introduced new relationships and integrated and interdependent actions, changing and transforming the result that might be expected from the mere juxtaposition of its constituents.

According to Morin (1991), complexity is everywhere and it cannot be reduced to a scientific or mental model.

It is governed by 3 principles: dialogic, recursion and organizational hologrammatic. The *Dialogic Principle* consists of trade, symbiosis and feedbacks between the systems, in particular, between human beings and society. Order and disorder are not antagonistic but complementary, which allows duality within unity. The *Organizational Recursion Principle* features the situation when cause produces the effect that becomes the cause of other effects. The *Hologrammatic* or *Multidimensional Principle* characterizes the relationship between the whole and its parts; it is impossible to conceive the whole without conceiving the parts and vice versa.

The Theory of Complexity incorporates *functionalist* and *critical* aspects. Functionalist, as it includes the concepts of integration, consensus, coordination and functional order. Critical, as it considers the concepts of conflict, change and disorder. The aim is not toward a single model methodology, but the coexistence of Epistemological Collisions in a critical perspective that considers multiple perspectives, such as social, environmental, science and technology.

A second alternative of integration of scientific knowledge is one that stresses the importance of *negotiation* as an opportunity to articulate different kinds of knowledge as a way to overcome the specialization that leads some to win and others to lose authority, as well as to limit the influence and impact on the techno-scientific production. The dialogue needs to be reliable, which normally occurs with the establishment of personal ties born on the motivation of doing research on real problems. The negotiation has the potential to anticipate and manage conflicts produced by different visions of the world, to establish dialogue, particularly due to the lack of communication, and financial resources which is a major bottleneck in the scientific production.

A combination of Social Networks of Production of Scientific Knowledge and negotiation suggests that such efforts are complementary, although they do not meet the demand for integration of scientific knowledge. Based on the theory of complexity, the integration work is initiated with the development of research questions shared with the review of scientific protocols and collective understanding of triangulation between different methodologies (quantitative and qualitative) in objectifying the generation of data and information that fit more naturally.

The impact of ICT in the promotion of scientific expertise in the development of a cyber culture leads to wider access and the disclosure of information and knowledge in virtual space, demonstrating the importance of defending the creation of technological platforms concerned with different social and academic requirements.

Therefore the establishment of new forms of work, building on the intensive use of ICT and Social Networks for scientific knowledge production, requires learning to foster more collaborative work between different research groups and to go beyond the establishment of integrated actions or cutting. Certainly, an important task for the research groups is the discussion of knowledge structures that reject or do not claim to replace the specificity of different areas of knowledge, but can develop interdisciplinary or even transdisciplinary methodologies.

3. Information Communication Technologies and the Scientific Knowledge Management

The vast amount of knowledge generated by scientific research institutions gave origin to discussions on the Management of Scientific Knowledge. The institutions are trying to find the best way to organize and disseminate the knowledge produced by their researchers and to provide environments and tools that foster collaboration between them in the attempt to develop innovations and new knowledge that can meet demands of society.

According to Osthoff et al. (2004, p. 1):

> *In the Management of Scientific Knowledge, we must create ways in which an institution can provide dynamic and effective forms to researchers for their knowledge acquired over time in order to perform their tasks, collaboration between them and the dissemination of individual knowledge, so that this knowledge be a significant part of organizational knowledge.*

When we try to practice the management of scientific knowledge, one must understand how knowledge is obtained, who possesses the knowledge, how it is formatted and how the barriers, physical and cultural, must be transposed to codify and disseminate it.

According to Morin (1991), scientific and technological developments are observable phenomena that are perfectly circular, so the science can produce the technology which allows the development of science which, in turn, develops technology. Technological advance increases the area in which a scientific development can be seen, perceived, observed and developed.

ICT contributes greatly to the improvement of scientific research, speeding processes, making possible the storage of large volumes of information and knowledge generated by research and, more recently, reducing distances and facilitating communication and collaboration between researchers. Thus, it is possible to highlight several initiatives where ICT has been used with the objective of contributing to the management of scientific knowledge.

The scientific knowledge management has become a topic of interest to various scientific communities, such as the Administration, Information Science and Computer Science. Programs of Technological Research & Development have been financially supported by several organizations. In the UK, we can cite for example the *UK e-Science Program* of the *UK Research Council*[1], and the *National e-Science Centre*[2].

In Computer Science, the many aspects of infrastructure that support scientific activity are treated within a discipline called e-Science. Scientific events have been organized to address this issue, such as the IEEE International *Conference on e-Science and Grid Computing*[3], already in its fourth edition. Since 2007, the "Workshop on e-Science" takes place periodically in the context of the Brazilian Symposium of Database and Brazilian Symposium of Software Engineering, as simultaneous events promoted by the *Brazilian Computer Society*[4].

In Brazil, some projects are worth noting, such as the e-Science from Unicamp and the *e-Science*[5] project (Oliveira et al., 2005, Sampaio et al., 2006) of COPPE/URFJ, which seeks to provide shared computing environments where researchers can exchange data, experiences, ideas, and seek information to perform their tasks, make decisions, learn and disseminate knowledge.

One Brazilian initiative of an integrated and interdisciplinary work is the *Research Program for Sustainable Conservation of Biodiversity - Program Biota*/FAPESP[6]. Initiated in 1999, its purpose was to systemize the collection, organization and dissemination of information on the biodiversity of the State of São Paulo, defining mechanisms for its conservation, economic potential and its sustainable use. After analyzing the material collected and how work was carried out, an Atlas of the region, which is constantly updated on line with public access, was constructed to be linked with other initiatives in Brazil and of other countries.

The science described here involves heterogeneous geographically distributed resources, such as computer systems, scientific instruments, databases, sensors, software components, networks, and people. These scientific efforts achieved through collaboration on a global scale are commonly coined as “e-Science”.

Some areas of IT research on the topic of e-Science are:

- *Grid computing* is a service oriented architecture where the user interacts with services or services that also interact with him. The grid concept is the opposite of a client-server architecture in which users interact with a physical entity like a server. The grid allows integrating resources and creating a logical layer that allows virtualizing and materializes such services. The Grid computing technology appears as a key calculation that allows the creation and management of infrastructure services, calculations based on the Internet for conducting e-Science and e-commerce at a global level. Scientific events have been organized to directly address this issue, such as the *IEEE International Conference on e-Science and Grid Computing*, which is in 2008 in its fourth edition[7] and has gathered a critical mass of researchers with significant results.
- The Web has over 20 years and, increasingly, it is part of our lives. Currently, the *Semantic Web* is the focus of several efforts from both academia and the industry, since it is considered to be the next evolution of the Web as we know it. The objective of building the Semantic Web is as comprehensive as the Web itself: create a universal medium for sharing. It is expected that the Semantic Web offers a new generation of applications for various segments such as business, education, science, and services. It makes necessary the creation of new research and the redefinition of old foundations. It may include contributions from and to several areas of knowledge, such as collaborative construction and management of scientific knowledge.

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[1] http://www.rcuk.ac.uk/escience/default.htm
[2] http://www.nesc.ac.uk
[3] http://escience2008.iu.edu
[4] http://sbbdes.ic.unicamp.br/index.php?option=com_content&task=view&id=46&Itemid=72
[5] http://www.e-science.unicamp.br
[6] http://www.biota.org.br
[7] http://escience2008.iu.edu

- A *digital library*, in the broadest sense, is a place where information is stored in an electronic format and can be obtained through the Internet, available in various formats: text, audio, video, image, etc. Digital library can be defined by its objectives, intentions and lifetime. The goal is to offer integrated services by providing access to resources in cultural and scientific collections. Digital libraries are intentionally thought for research and learning, and their lifetime show that they can provide access to information preserved during relatively long time periods.
- Increasingly, scientists are organized in networks or research groups having the idea of seeking common solutions to problems. In general, such groups are formed by researchers from various institutions, often geographically remote, requiring the use of ICT to make teamwork effective. The aim of the scientific community that studies the CSCW (*Computer-Supported Collaborative Work*) is to investigate how group work can be assisted by ICT to improve the performance of groups in developing their tasks. Technology-based groupware –software developed to assist groups of people that are physically distant but working together –, the CSCW makes possible the development of environments where group work can be performed on a synchronous as well on an asynchronous way, a work that would be difficult or even impossible to be achieved without any use of a computer.

4. Scientists and Socio-Environmental Problems

Increasingly, society delegates to scientific communities the mission to enlighten the choices of governance. The expected recommendations form the basis for the discussion of charters, laws, and ethical rules negotiated by communities. It is obvious to everyone that their implementation by the institutions will greatly impact communities' cultural, economic and social aspects. The problem that we address here is to find a process that will benefit other scientific communities and institutions that have to confront problems of similar complexity: hunger, exclusion, climate change.

Society obviously does not demand that the scientific community find a universal solution to all problems, not even a formal definition, but find solutions that can measure risk, feasibility and usefulness of their implementation. Notwithstanding, can we find principles that enable an interdisciplinary scientific community to develop useful, practicable and risk-measurable recommendations, while debating with the economic and social community?

4.1. Thinking the Amazon Region

Let us start by specifying an example, that is understood as a multidisciplinary, interdisciplinary and transdisciplinary scientific approach. Take a biosphere as the Amazon and assume, as is the case for at least 10 years, which the Amazon is observed by many scientific and socio-environmental communities, outsourcer Brazilian wishes to be informed of the consequences of their regulations. Suppose that each discipline produces sensors that allow them to collect and register facts that will be scientifically interpreted and produce forecasts. Suppose that the college made up of all the sciences observing the Amazon is able to take into account in its calculations the prediction of results proved by another community. Finally, suppose that the college is able to inform parliamentarians to legislate so as to channel the economic and social activity.

We have defined a framework by introducing a dialectical cycle regulation that we will detail (from the lower left corner and turning in the opposite direction to clockwise). The *multidisciplinary* scientific activity observes the effects of human activity on the Amazon rainforest. An *interdisciplinary* diagnosis will inform a *transdisciplinary* nature of politics. This will force by standards (principles, laws) the socio-economic activities in the Amazon region.

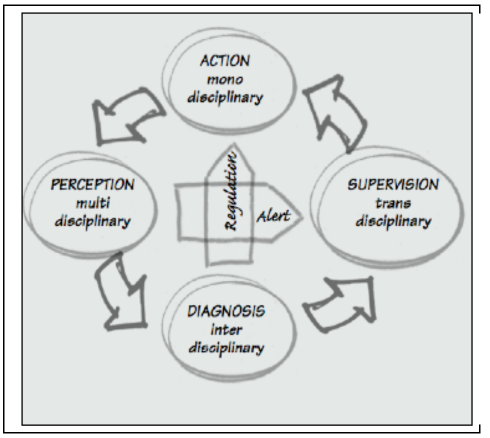

Figure 5: The cycle regulation

Two operations consolidate the cycle:

- a transaction alert, which allows a scientific discipline to directly inform the supervision when it anticipates a too serious malfunction to be caught by regulation;
- an operation control, which acts directly on the socio-economic action, preventing the passage through supervision not unnecessarily slowing down the time for the action.

Such a system has two useful features:

- supervision is early and takes place after the action: regulatory intervention introduces a kind of a posteriori control;
- alert signals, anticipating the diagnosis, characterize a kind of intuition of the system: if we take a system and double-loop it, the self-warning system will enforce a decision to oppose any regulation become unsafe.

Take another example: that of the carbon account and the carbon tax. The carbon account is an indicator belonging to the collection system and evidenced by several scientific disciplines. The carbon tax is a device belonging to the ruling system that helps regulate gambling socio-economic development. We can consider that in the social game, if carbon account is a signifier then the carbon tax is its significant. Thus one of the virtues of the warning system is to construct the signified attached to an indicator.

This diagram shows two roles expected of scientists: the whistle-blower and the modeling involved in regulating the system. Alerts report abuses of the model or the need for reinforcement.

Note that there is no need to be a scientist to give the alert. But this prophetic work requires courage and an ability to persuade. Cassandra, daughter of Priam and promised to Apollo, refused him after he gave her the gift of divination. In revenge, Apollo denied her the ability to persuade the validity of its predictions.

There remains the question of the collective status of scientists: are we Cassandra unable to persuade politicians to change their worldview? In the next section we have something to propose in regard to that.

4.2. A Structural Framework for Defining the Triple Loop Regulation

The temporal behavior

The previous causal cycle is a succession of operations realized by a society observed by scientists, regulated by lawyers, managed by politicians to whom it will obey or not.

We will now propose a temporal circulation of this causal cycle, time being considered as a succession of periods separated by crises. A crisis is manifested through rise of a contradiction.

At any time, an activity relies on the analysis of the present following four modalities: actual, real, virtual, potential. Actual is opposed to potential, and real to virtual. This means that we do not encounter a crisis as long as *any real situation is not virtual* and *any potential situation is not actual*. The non-contradiction axiom implies that actual is contrary to virtual: *nothing can be both actual and virtual*. We assume the excluded middle axiom: *real is subcontrary to potential*, which means *at any time everything is actual or potential*. To conclude, we have also subalternate relations: *anything actual is real* and *anything virtual is potential*.

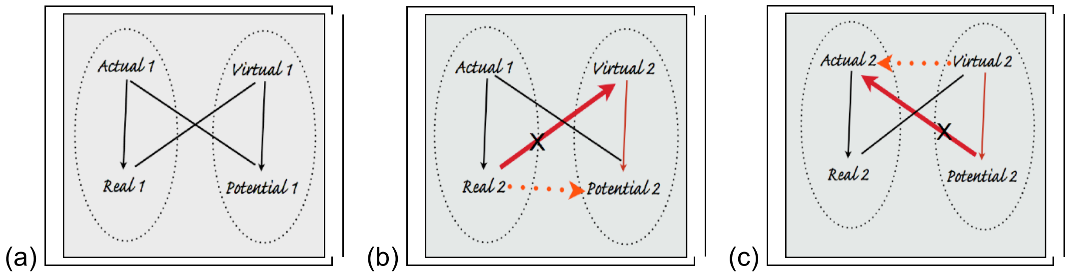

Figure 6: (a) the square of oppositions that associates modalities that are actual and real at instant 1; (b) an evolution of real 1 into real 2 provokes a contradiction that enforces an evolution of virtual 1 into virtual 2, implying evolution of potential 1 into potential 2; (c) the evolution of potential 2 provokes a contradiction that enforces an evolution of actual 1 into actual 2.

Aristotle distinguishes what is *actual* from what is *potential*. In our case, we complete the set of modalities: in the first group we have both the *actual* and *real* modalities, and in the second group we have the *virtual* and *potential* modalities. A crisis is signaled by a contradiction between real and virtual that implies the necessity to stabilize the model by changing the time period.

The causal and temporal behavior for debate games

In order to constrain the temporal behavior of the debate game, it is enough to assign a temporal modality to each acting collectivity. Let us consider that the monodisciplinary action of the collectivities perform actuality and that the pluridisciplinary action of the scientific collectivities provides the perception of reality. The consideration on reality is led by the interdisciplinary action of administrative personnel that establish trends constituting the virtuality of the system operation. The transdisciplinary action of the politicians produces action potentialities.

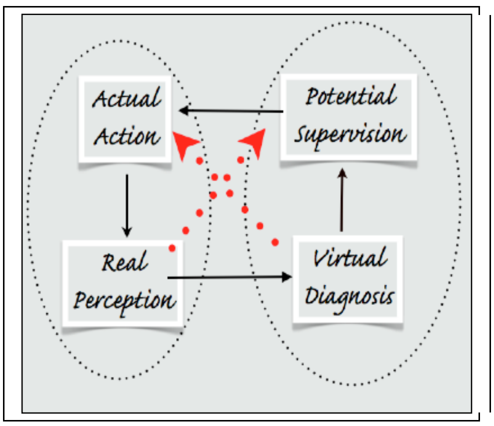

Figure 7: In a critical situation critique, different collectivities act collectively via diagonal arrows in order to produce a new period of stability. Diagonal arrows express the adaptation and evolution abilities of the system.

From the previous representation of the dialectical framework, we will sketch a formal model that will establish certain properties; the interpretation will complement the previous analysis. If we detail the semiotic structure of representation, we have systems connected by arrows; each system has objects and relationships between objects. For example, in the socio-environmental system, there are agents who act in an environment. Another arrow reflects the system on Socio-environmental perception as a multidisciplinary approach. Scientific communities will therefore reflect the behavior of actors in information about those behaviors. This information can be made from facts perceived or from theoretical results, including the basis for each discipline and theoretical corpus. This diagrammatic representation is very compact for all the observation work in the Amazon and is summarized here by an arrow between the systems of action and perception. It also has the merit of giving rise naturally to formalization via category theory (Luzeaux, 1998a, 1998b; Luzeaux, 2009; Mac Lane, 1997). We will recall some basic notions in the following paragraphs.

A cornerstone of the category theory is to develop systematically a relational point of view: everything can be defined as an arrow (i.e. intuitively a relationship or transformation, or more precisely a morphism) between objects, and the objects themselves that can be defined simply by using the arrows (in fact, a simple conceptual difference, a priori, between an arrow and an object is that the arrow can be composed and therefore defines a "from" and a "coming to"; yet an object can be defined as an arrow whose "from" and "coming to" could be seen as confusing). Therefore one has objects and arrows, i.e. the morphisms between them. We can define concepts such as products, co products, etc, which are generalizations of the usual notions: the main difference is that in theoretical category it is possible to define them on the purely relational point of view, which gives them great generalization ability. It then becomes possible to reinterpret the results in various branches of mathematics (commutative algebra, algebraic topology ...) as actually instantiations of the same result demonstrable through theoretical category. It is in that sense that theoretical category unifies, a priori, distinct concepts within a single concept, where one can provide general results, that provide specific answers inside each specific areas.

Applying recursive definitions, we can consider a particular category whose objects are themselves classes, in which case the morphisms between those composite objects are called functors. If we express the action of a functor, we see that a functor between categories can be defined as an association between the objects of the first category of objects to the second ones, and the morphisms of the first of them to the morphisms of the second of them, so that a morphism between two objects of the first category is sent to a morphism between images of objects. Thus, a functor is a transformation that preserves the basic structure between the categories considered. If we take even more of hindsight, we can consider the category whose objects are functors, then the morphisms between functors are natural transformations. The interest of these concepts is to describe a priori any mathematical concept, albeit at the cost of conceptual efforts nonzero for the uninitiated, but their largely demonstrative balance.

Categorical model

Before we conclude that section dedicated to methodology, let us recall the objective. We want to produce idealized “mathematical” figures that help formulate worlds such as ideospheres and relate them with other worlds such as the infosphere. In order to do that, we have taken the particular example of a public debate and we have exhibited functionalities that structure it: the causality of the argumentations, the succession of periods and their transition. We have featured an operation called *adaptation*, able to translate constraints coming from the diagnosis into constraints on action.

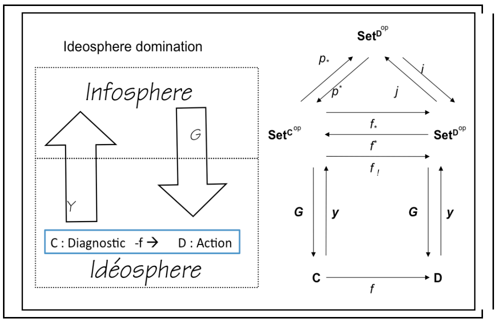

Figure 8: A correspondence between a conceptual model and a formal one

Without delving into details, let us hint at the usefulness of the categorical model. The figure illustrates a graduate-level theorem on topos classification: from a given *f* between two categories *C* and *D* with minimal properties, a mathematical structure Set^{Dop} can be constructed with the relevant mappings. Let us only mention that this illustrates the fact that the dominance schema between infosphere and ideosphere appears correct: every functor is formally well defined, the representation functor is Yoneda's and the interpretation functor is its left G. The categorical diagram tells us that there exists an ontology (the mathematical structure mentioned previously) representing the behavior of actions and that the constraints on actions are formulated by expressions using universal and existential quantifiers. Hence, the mathematical model gives a formal justification to the concepts we wanted to illustrate, with minimal properties required on the various structures.

Returning to our original topic, it is urgent to bring the Figure 1 in terms of categories. This will be illustrated very briefly later in this paper (see the demonstration of intuitive end-section).

Formulate the question:

- suppose that chance does not govern the behavior of the Amazonian forest and there is a logical formulation, even very abstract, and laws for the regulation of socio-environmental Amazon;
- assume that this formulation is too complicated to be calculated with our computing resources;
- suppose also that we have a "super-mathematician" (as a problem solver) not restricted by its activity of thought, neither by time nor memory resources, and that spends his time providing theorems informing us about the behavior of the environmental system.

The question we will consider is: Are interdisciplinary and transdisciplinary activities conducted by agents with finite resources able to find what this super-mathematician is?

In other words, can the laws of nature be at reach by a scientific community? The answer we give is yes. But to answer precisely, we need some definitions and considerations.

Multidisciplinarity is when several scientific disciplines come together to study a given problem. It is assumed here that no community is omniscient because each has only a partial view of the problem.

Interdisciplinary is when communities share their true, false or unknown results. Each community is then influenced and influences other communities through its published results.

A transdisciplinary approach takes in consideration that each community publishes in isolation. However there are regular appointments in each community that shares its published results.

Each community sets out again this appointment by taking some new results of others. It thus developing its own publications or by changing the status of the latter is proposing new results (Martin & Sallantin, 2009).

The social game of multidisciplinarity: Consider a scientist in an interdisciplinary activity uses in its argumentation statements proved in another community.

The social interplay of interdisciplinary: Consider a scientist in an interdisciplinary activity uses in its argumentation statements proved in another community.

The principle of interdisciplinarity is to admit as demonstrations some results proved by other communities that one cannot prove by himself. We can think logically in admitting the results proved by others and inaccessible to our demonstrations.

In computing, power is increased by distributing demonstration trial activity, taking into account regular results of others.

A scientific discipline does not practice interdisciplinarity on its own results. An interdisciplinary approach is required when there is no discipline omniscient and omnipotent able to solve the problem without intervention from others.

The social game of transdisciplinarity: Consider a player that on a transdisciplinary activity must take the risk of making assumptions about the world by declaring certain real-looking statements.

Supposing that those statements are true will produce some effects on socio-environment. This will initiate the multi-and interdisciplinary work that will, themselves, may trigger alerts indicating a false assumption. We can consider the players of transdisciplinarity as parliamentarians making choices (assumptions as truths on which they will have to return).

The precise answer to the question: A group of scientists operating under a multi-, inter- and transdisciplinary approach is able on doing a finite number of hypotheses to prove theorems of the super-mathematician after a finite number of errors.

The intuitive demonstration of this assertion derives from a part of a general result related to the categorical formalism used, and to a compact logical argument which reduces the activity of any super-mathematician with finite steps resolution within assumptions and mistakes. Indeed, we can define:

- A first category includes items such as systems "action" and "perception", and morphisms as arrows between them, that is to say in terms of interpretive work of scientific observation shown earlier in the Amazon case study;
- A second category, where the objects are the "diagnosis" and the "supervision", and the morphisms the arrows between them, which translates to this work the introspection and exchange inherent to scientific rationality, being it individual or collective;
- A pair of functors between these two categories that compose the dialectical framework, which we assume that they defines an addition (a mathematical property between the two categories reflecting the fact that there is a match to a certain level of abstraction between operations performed in each category: if F and G are the functors considered respectively from the first in the second category for F and in the opposite direction for G, A an object of the first category, B an object of the second category, then there is a natural bijective transformation between all morphisms linking FA to B on one side, and all morphisms between A and the other GB), which is a strong mathematical assumption, but not as a priori point of view of modeling, because it simply reflects the fact that a player of one discipline knows how to use that discipline, after translation into its own corpus, the results of others, and that reciprocally the others will also know how to use their corpus after a new translation, what is what the actor has managed to make knowledge of others in his own corpus: it is not a formulation of the necessary reflexivity (in the sense of a partial possibility of identification between an object and the representation of the representation of this object).

Addition then gives a mathematical sense of a regulation cycle and allows the demonstration that it closes on itself after two courses (for the amateur categories warned: this is because the addition defines a monad, where the composition operator corresponds precisely to a cycle; by definition the dual application of the operator is naturally isomorphic to the simple application, hence the result), where the closure of the collection of theorems is demonstrated.

The compactness mentioned in the statement derives from the fact that the use of different communities through the addition can actually overcome the limits of finitude.

This result has a metaphysical significance as it serves to enforce consistency to the system considered. Once ultimately it is the result we wanted to have. Indeed, one wishes that a collective scientific activity illuminates the parliamentary decision when it has to regulate a complex system of laws keeping a state of sustainability.

5. Discussion and Conclusion

This reflection on the collective scientific activity shows the different contexts that act on it: its operational technique, its political significance, and its epistemological limits. For us, science is not reducible to its instrumentation by the ICT tools and suffers from bias imposed by, for instance, biometrics science that measures its activities. However, some problems which are now the objects of science would not exist without these technologies. Scientific activity is not confined to his incitement by the political demands. Yet some problems, such as management of the Amazon or the global warming issues would not exist in science without their relationship to political activity.

This last point opens the question of specialization of the sciences which are distinguished by their subject and their tools, while remaining unified in their confrontation with the elusive boundaries of knowledge. We believe in this new important scientific activity: the scientist has a dual activity, he is a sentinel or whistle-blower on socio-environmental issues. He is also the producer of speculation that yield proven results shared by other scientists within an interdisciplinary exchange. This exchange helps deepen and establish various behaviors that are legitimate only if they are meaningful to legislators, due to their ability to reject temporarily invalid hypotheses.

Scientific activity is thus faced with technological, political issues, as well as its own activity itself. We have exhibited an internal structure and its structural opportunity to discuss structuring oppositions between visions of scientific activity.

The form of regulation of socio-environmental system proposed corresponds to forms of governance being put in place that harmoniously combine forces. The successive crises advance knowledge on the Earth system. The production of such knowledge structure allows each one to act considering the reasons of others.

In conclusion, this study of formal properties of the scientific noosphere shows that its authors advocate a scientific activity driven by a joyful passion – à la Spinoza –, that of discovery. Indeed, the structural framework does not limit other contextual deployment of the scientific noosphere of ideas perceived of our actions in our biosphere.

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