Knowledgedynamics and Thermodynamics

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The purpose of this paper is to present a metaphorical analysis for Knowledgedynamics using the main concepts of Thermodynamics. Following the Andriessen's method we are going to define Thermodynamics as a source domain, and Knowledgedynamics as the target domain. Our analysis will discover the semantic kernel of this metaphor and the way in which we can benefit of it. In the same time, we shall demonstrate the complexity of the knowledge domain and the fact that this metaphorical analysis should constitute only a first step in defining the concepts and the laws of the new field of study.
***Keywords**: energy, heat, temperature, knowledge, cognitive work, emotional heat.*

Mental models

We are living in a very complex world which is infinite in any meaningful direction we may consider. However, from biological and psychological point of view, our brain power is limited. It looks like a living paradox our effort to understand such an infinite world using a finite mind. And the only way to escape this paradox is to construct *thinking patterns* or *mental models* (Bratianu, 2007a; Gardner, 1993; Gardner, 2006; Senge, 1990; Sherwood, 2002; Simon, 1996). These thinking patterns are cognitive approximations of the real world, which have been developed through our education in family, school, university and a given cultural environment. As Senge (1990, p.175) remarked, our "*mental models determine not only how we make sense of the world, but how we take action*". Among many such mental models, *metaphors* play an important role in understanding new phenomena, structuring our thinking, and developing new concepts. A metaphor is not just a semantic similarity between two concepts, but an instrument to conceptualize a new cognitive approximation using a well known concept. It helps in providing a perspective for the new concept, emphasizing certain key characteristics and ignoring others. In our research, the source domain is represented by the concept of *energy*, and the target domain is represented by the concept of *knowledge*. The metaphorical entailments are given by the semantic intersection of the two domains (Andriessen, 2007). The larger this semantic intersection is the better cognitive approximation we get by using this metaphor. Also, we identify some characteristics of the source domain not used by metaphor, as well as some characteristics of the target domain not covered by the source domain. Now, we are going to introduce for *knowledgedynamics* the metaphor of *thermodynamics*, due to a generous semantic intersection of the two concepts. However, the limitations of the source domain will stimulate researchers to find out a better cognitive approximation for this generic concept of knowledge.

Cognitive and emotional knowledge as mechanical and thermal energy

This is a challenging metaphor since we may use the fundamental concepts of thermodynamics. As a science, *thermodynamics* is concerned with the generation, transport, and dissipation of heat as a form of energy. That means also the transformation process of mechanical work into heat, and of variation of heat into mechanical work in complex systems. The general equation of these transformations can be written as follows:

$$\Delta E = W + Q \quad (1)$$

where: ΔE – energy variation from an initial state to a final state; W – mechanical work performed by the system, and Q – heat input to the system. By analogy, we may write for the target domain:

$$\Delta K = KW + KQ \quad (2)$$

where: ΔK – knowledge variation; KW – cognitive work, and KQ – emotional heat.

This last relation is strictly qualitative and it introduces a difference between a cognitive process and an emotional one. By *cognitive work* we may refer to any knowledge processing event which is capable of generating action at individual or organizational level. In the field theory, any non-uniform distribution in time or space generates forces, and any variation of these forces generates fluxes which tend to produce uniformity. This is true for the knowledge field as well, and we may coin the concept of *cognitive work* as a result of variation of cognitive fluxes at the individual level or organizational level. A cognitive work is actually any flux which may generate, or which can be generated by a knowledge field variation. It is a step further from the concept of *working knowledge* (Davenport and Prusak, 2000). By *emotional heat* we may consider the emotional flux which has been induced or produced as a result of a knowledge field variation. Let us consider that we are waiting for the final result of a job interview. When it is communicated to us, we have a variation in our knowledge level, and we perform a cognitive work in interpreting this result. In the same time, an emotional flux is generated according to our expectation level: if we get the wanted job we are happy, if not, we are sorry. Like mechanical energy, the cognitive work has an extensive dimension which eventually can be measured. Like thermal energy, the emotional heat has both extensive and intensive dimensions. Although we cannot measure now the intensity of a certain emotion, we can differentiate emotions based on their intensities, which means we can perform a relative evaluation of them. Introducing emotions into the knowledge metaphorical analysis it is in concordance to the Japanese view of oneness of body and mind (Nonaka and Takeuchi, 1995).

The second law of thermodynamics has many formulations and interpretations. However, the kernel of this law is that heat can flow by its nature from a body with a higher temperature, toward a body with a lower temperature. These two bodies can be in direct contact, or not. The reverse process can be done only by performing mechanical work. Using our metaphor, we may say that in the target domain knowledge can be transferred only from a person having a higher knowing level toward a person with a lower knowing level. In the knowledge transfer and sharing we may include both tacit and explicit knowledge. In knowledge intensive organizations, one core competency is knowledge sharing. People need to actively share, discuss their practice which is generating tacit knowledge, and see how managers are part of this sharing process (Debowski, 2006). "*While knowledge is often thought to be the property of individuals, a great deal of knowledge is both produced and held collectively. Such knowledge is readily generated when people work together in the tightly knit groups known as communities of practice*" (Brown and Duguid, 1998, p.91).

Knowledge entropy

The concept of *entropy* has been defined for the first time by R.J.E. Clausius in 1865, in relation with the second law of thermodynamics. Clausius' definition of entropy change could be expressed verbally as being the amount of energy dispersed reversibly at a specific temperature T. From a statistical viewpoint, the entropy is the degree of disorder or chaos that exists or is created, a connection that has been revealed by investigations of Boltzmann and Gibbs in statistical physics. Entropy can be express as (Schroedinger, 1967):

$$\text{Entropy} = k \log D \qquad (3)$$

where k is the so-called Boltzmann constant, and D is a quantitative measure of disorder. Also, D can be interpreted as a probability of a macrostate of a given system, produced by its chaotic microstates. Transitions from less probable to more probable macrostates and towards equilibrium all increase entropy and consume exergy, the work potential of the given system. In the source domain of energy, entropy can be interpreted also as a measure of energy distribution and the capacity of the energy field to do useful work. The higher the entropy, the less value of the energy field (Handscombe and Patterson, 2004).

In the target domain of knowledge, entropy can measure the distribution of the knowledge field at the organizational level. A highly structured and non-uniform knowledge field has a low entropy value. This is a typical situation in the industrial management, where the management hierarchy is highly vertically structured and top-down knowledge flow is very well controlled (Robbins and DeCenzo, 2005).

In the new knowledge creating companies, the knowledge field is less structured due to a flat management hierarchy and an intensive knowledge transfer on both vertical and horizontal directions. "*Hierarchies are very good at aggregating effort, at coordinating the activities of many people with widely varying roles. But they're not very good at mobilizing effort, at inspiring people to go above and beyond. When it comes to mobilizing human capabilities, communities outperform bureaucracies*" (Hamel and Breen, 2007, 62).

Entropy can be in the target domain an important indicator to describe organizations and their management performance. For instance, the entropy of a platoon of soldiers is very law because they are highly constrained by regulations to execute the top-down orders. By contrast, the entropy of a creative company with a lax lattice management is high since knowledge is flowing in all directions trying to level up the organizational knowledge field. In is interesting to conclude that management is by its nature *anti-entropic*, since it implies order and well defined knowledge clusters. Knowledge entropy is reducing by performing cognitive work and keeping at a very low level the emotional heat. The final result is a perfect mechanical organization operating by bureaucratic procedures. It is a very stiff organization with a low innovation level and a low adaptive capacity. The new types of organizations are more flexible, with less structured managerial hierarchies, and higher level of innovation (Leonard-Barton, 1995; Christensen, 2003). That means a higher level of knowledge entropy. We may say that these new creative companies developed an entropic management, keeping a dynamic equilibrium between the cognitive work and the emotional intelligence. The future of management is the *entropic management*, which means a 180 degrees change in the organizational dynamics.

Conclusions

Metaphorical analysis is a very useful way of developing new concepts and theories, by using a source domain with well known concepts. Our research presented in this paper is concerned with choosing for *knowledgedynamics* the *thermodynamics* metaphor. Among the most important similarities we found are the followings: energy and knowledge can be considered as dynamic fields; energy correlation with work and heat through the second law of thermodynamics can be paralleled by knowledge correlation with the cognitive work and emotional states; entropy can be used successfully in the knowledge field with new interpretations; synergy from the source domain can be projected into syntropy from the target domain.

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