

# ENERGY METAPHORS FOR KNOWLEDGE DYNAMICS

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*Abstract. The purpose of this paper is to present a new perspective in understanding knowledge by using energy metaphors. Most of the research conducted so far is based on using metaphors based on tangible objects and linear metrics. The new perspective introduces the concept of knowledge field and knowledge dynamics based on energy metaphors. Thus, instead of using the old dyad of explicit and tacit knowledge, we introduce a new dyad containing cognitive and emotional knowledge, and the reciprocal transformation of one form of knowledge into the other one. The energy metaphors can be extended to developing an entropic model for the intellectual capital, too, where knowledge is the main constituent.*

*Keywords: explicit knowledge, tacit knowledge, cognitive knowledge, emotional knowledge, metaphor, thermodynamics*

## 1. INTRODUCTION

We are living in a complex and infinite world. However, our mind is limited in its capacity of representing and understanding this infinity in time, space and complexity. In order to understand this world, our mind developed in its millennial existence *thinking models*, as cognitive and emotional representations of it [1-5]. As Senge remarks, our *“mental models determine not only how we make sense of the world, but how we take action”* [2, p. 175]. Among many such mental models, *metaphors* play an important role in understanding new phenomena, structuring our thinking and developing new concepts [6]. A metaphor is not just a semantic similarity between two concepts, but an instrument to develop a new cognitive approximation using a well known concept [7-9]. In this case, we refer to a conceptual metaphor [10, pp. 181-182], *“which can be defined as conventionalized and systematic mappings (sets of correspondences) between distinct conceptual domains.”* As Andriessen remarks [7], choosing uncsciously a metaphor has an important impact on how we reason about knowledge, what could be seen and what remains hidden within an organization, and what could be an appropriate solution of a given problem.

For more than two millennia, reason has been taken for granted as being the defining characteristic of human beings. Reason means processing cognitive knowledge and making decisions in any environment of our life. Recent

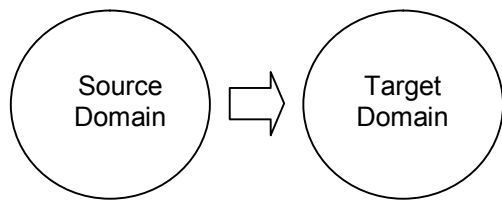
developments of cognitive sciences demonstrated that reason is not disembodied, as tradition considered so far, but it arises from the nature of our brains, bodies, and bodily experience. *“Reason is not completely conscious, but mostly unconscious. Reason is not purely literal, but largely metaphorical and imaginative. Reason is not dispassionate, but emotionally engaged. This shift in our understanding of reason is of vast proportions, and it entails a corresponding shift in our understanding of what we are as human beings”* [6, pp. 4-5].

The purpose of this paper is to shed light on knowledge understanding by using energy metaphors, that means a completely new perspective of the knowledge meanings spectrum. The next sections of this papers are structured as follows: first, we shall discuss the most used metaphors for knowledge developed so far, and then we shall introduce our energy metaphors and their contribution to the knowledge debate.

## 2. KNOWLEDGE AS STOCKS AND FLOWS

Conceptual metaphors work in the following way: they contain two semantic domains, one of which is well known and another one which is unknown. The known domain is called the *source domain*, since we extract from it a series of meanings and semantic relations. The unknown domain is called the *target domain*, since we transferred to it what can be transferred from the known domain (see Fig.1). However, the transferred meanings and relations constitute only a part of the source domain. Thus, in the source domain there will remain a good part of what is not used, while in the target domain there will remain some unknown semantics what the metaphor cannot disclose. The power of a metaphor is given by what it can transfer from the source domain to the target domain [7, 8, 11, 12]. Thus, *“Metaphors not only enable the reflection and communication of complex topics and the anticipation of new situations, the use of different metaphor models also affects further perception, interpretation of experiences and possibly also subsequent actions”* [13, p. 4].

In Knowledge Management, knowledge is considered a resource, and thus the simple analogy with tangible resources created the first metaphor: *knowledge as an object*. Thus, knowledge can be



**Fig. 1** The conceptual metaphor structure

accumulated, acquired, delivered, held, located, moved, exchanged, packaged, sold, stored, and so on. In this perspective, knowledge behaves in organizations like tangible objects, and it can be evaluated using linear metrics. The generic meaning of this type of metaphors is understanding knowledge as a *stock*. It is a quite limitative metaphor, but unfortunately used extensively due to its attractive simplicity.

Knowledge as an object is a static metaphor, and it cannot explain knowledge transformation from explicit into tacit forms, as it is conceived in the SECI model of knowledge dynamics developed by Nonaka and his colleagues [14-17]. The SECI model is based on the dyad of explicit and tacit knowledge, and contains four major knowledge processes of transfer or transformation: socialization, externalization, combination, and internalization.

*Socialization* is the process of transferring tacit knowledge from one person to the other when they are working together. Nonaka considers that socialization is the most important process in Japanese companies since it involves the hidden and sticky part of all knowledge created at individual level, that is tacit knowledge. In his view, tacit knowledge is “*personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective and the value system*” [16, p. VIII]. Tacit knowledge is a result of direct experience of an individual within a given *Ba*, where *Ba* is a dynamic and complex context where knowledge is created and transferred.

*Externalization* is an individual process of transformation of tacit knowledge into explicit knowledge. That means to transform something we got through direct experience, that is in our unconscious, into something we are aware of since it is present in our conscious. The advantage of explicit knowledge is that it can be articulated and transferred to other people using the formal language, and formal channels of communication.

*Combination* is the transfer of explicit knowledge from one person to another by using the natural language. It is “*the process of creating new network structures of explicit knowledge by integrating individual explicit knowledge into organizational knowledge structures. Unlike externalization that is purely individual process, combination is a social process based on the communication property of explicit knowledge*” [18, p. 162].

*Internalization* is an individual process of transforming explicit knowledge into tacit

knowledge. It is the reverse process of externalization. It is closely related to learning-by-doing. Internalization means that new acquired knowledge through combination is integrated into the matrix of known knowledge, and then transformed into tacit knowledge.

As Nonaka remarks, “*The most prominent feature of knowledge, compared with physical resources and information, is that it is born of human interaction. It is not a self-contained substance waiting to be discovered and collected. Knowledge is created by people in their interactions with each other and the environment*” [17, p. 7].

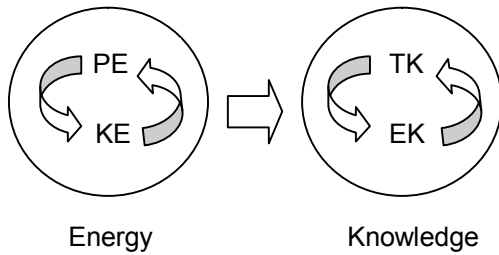
In developing this model for knowledge dynamics, Nonaka used mostly the metaphor *knowledge as flow*. This metaphor has been used frequently also by Davenport & Prusak [19], and by Nissen [20]. The metaphor is based on the Newtonian mechanics applied to fluid flows. Actually, it is a composed metaphor, since it involves the fact that knowledge is like a fluid, and it can flow when the fluid is under a pressure field. This mechanical model has inspired Nissen [20, p. XX] to imagine knowledge as a fluid flowing within an organization: “*To the extent that organizational knowledge does not exist in the form needed for application or at the place and time required to enable work performance, then it must flow from how it exists and where it is located to how and where it is needed. This is the concept of knowledge flows.*”

However, this metaphor is rather incomplete since in fluid dynamics a flow is defined with respect to a field of forces, and a pressure difference between two points or two limits. For instance, water flows in rivers from a higher level to a lower level with respect to the sea level. In industry, water flows through a pipe due to the pressure difference between the entrance and the exit of the pipe. This kind of specification lacks entirely in the metaphor *knowledge as flow*, which constitutes a severe limitation.

Considering together *knowledge as stock* metaphor, and *knowledge as flow* metaphor, many researchers use, for organizational knowledge, the composed metaphor *knowledge as stocks and flows*. That means catching the meaning of knowledge accumulation and storage within an organization, and the meaning of flow throughout the organization. Although it is a better representation of organizational knowledge, it still has many limitations coming especially from the perspective of Newtonian fluid mechanics. The most important one is the linearity property. As demonstrated by Bratianu [21], knowledge is highly non-linear and it cannot accommodate linear metrics for its evaluation. Also, in any organizationa knowledge is distributed non-uniformly, and as a result of that we may talk about knowledge flows.

### 3. KNOWLEDGE AS ENERGY

The metaphor *knowledge as energy* is a very complex one since it changes the paradigm of representing and understanding knowledge. In this metaphor, the source domain is represented by the semantic field of the *energy* concept, while the target domain is represented by the semantic field of the *knowledge* concept (see Fig. 2).



**Fig. 2** Mechanical energy metaphor structure

Energy is not a substance, rather a field of forces. It is spread in space and time, and it can be found in different forms: mechanical energy, thermal energy, gravitational energy, electric energy, magnetic energy, nuclear energy and so on. The main characteristic of energy is that it cannot be created, it cannot be destroyed, but it can be transformed from one form into another form, in accordance with the energy conservation law. For the first stage of our metaphorical analysis we shall consider only the mechanical energy. Thus, in the energy domain we distinguish two forms of mechanical energy: potential energy (PE), and kinetic energy (KE). Potential energy reflects the position of a given body with respect to the gravity field, while kinetic energy is the form able to generate mechanical work. According to the energy conservation law, potential energy can be transformed into kinetic energy, such that value of their sum to remain constant. Also, kinetic energy can be transformed into potential energy by consuming some mechanical work.

The first property that can be transferred to the knowledge domain is that of the field existence. Thus, knowledge is not anymore considered as an object, but as a *field of forces*. This field is nonlinear and distributed nonuniformly in space and time. That means that the field is capable of generating variation of knowledge in time and fluxes of knowledge in space. That means a completely new perspective on representing knowledge as a nonsubstance entity, and in a dynamic conceptual model [8, 18]. At the organizational level, the knowledge field is conceived as an entity able to integrate all individual knowledge contributions from a certain

organization, and to map the whole organizational knowledge as a continuum in time and space.

*Knowledge as energy* is a very powerful metaphor since it allows to conceive new characteristics for knowledge that were not possible with the previous metaphors. In the knowledge domain we distinguish between two forms of knowledge: tacit knowledge (TK), and explicit knowledge (EK). Tacit knowledge represents our unconscious knowledge obtained mostly from direct experience. It is similar to the potential energy. While potential energy of a body varies in space and time with respect to its position in the gravity field, tacit knowledge varies in space and time with respect to the experience gained by an individual. Explicit knowledge is a result of our conscious mind, and it is decisive in understanding the world we are living in, and in making decisions and initiating actions. From this point of view explicit knowledge is similar to kinetic energy.

The most important feature of this metaphor comes from the fact that potential energy can be transformed into kinetic energy and vice versa. That means that we may consider also the transformation of tacit knowledge into explicit knowledge and vice versa. The transformation in itself has been postulated by Nonaka in his SECI model, through externalization and internalization processes. This metaphor validate actually the postulated transformation, and allows for new interpretations of knowledge dynamics. From a mathematical point of view, for the energy domain it is known that the total energy (E) results as a sum of the potential energy (PE) and kinetic energy (KE), and it is constant:

$$E = PE + KE \quad (1)$$

Similarly, for the knowledge domain we may write that total knowledge at the individual level (K) represents the sum of the tacit knowledge (TK), and explicit knowledge (EK). However, unlike energy, knowledge can be created and destroyed. That means that for the knowledge domain we cannot apply the conservation law. Relation (1) can be written only as a qualitative relation as:

$$K = TK + EK \quad (2)$$

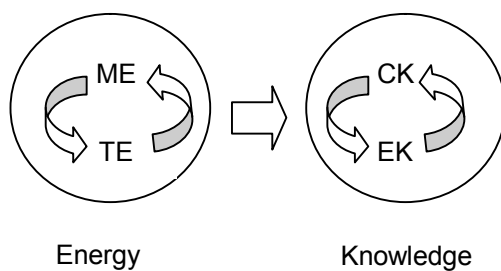
The above metaphor is based on the Nonaka's dyad composed of tacit knowledge and explicit knowledge. Since we do not know how much tacit knowledge we have, and what is its actual composition, it is very difficult to operate with it.

Bratianu introduced a new dyad composed of *cognitive knowledge* (CK) and *emotional knowledge* (EK), which represents the nature of knowledge much better [22, 23]. Cognitive knowledge represents the rational knowledge that can be expressed as explicit knowledge. Thus,

cognitive knowledge can be shared with other people and can be processed by the rational intelligence, i.e. mathematical and logical intelligences in the Gardner's framework of multiple intelligences [24]. Cognitive knowledge can be through codification into documents or data bases, stored and retrieved, and transferred to other people or organizations. Codification means to transform knowledge into some specific formats and then make them available to the whole organization [19, 25, 26].

While rational knowledge is a product of European philosophy, *emotional knowledge* is a product of Japanese philosophy [14-17]. However, cognitive sciences and brain sciences demonstrated its importance and the role it plays in making decisions [27-30]. Recognizing that emotional knowledge was neglected within the realm of research and practice, Le Doux demonstrates that human brain is both cognitive and emotional: "*But now it is time to put cognition back into its mental context – to reunite cognition and emotion in the mind. Minds have thoughts as well as emotions and the study of either without the other will never be fully satisfying*" [30, p. 39].

Cognitive knowledge has only got one dimension that allows measuring knowledge based on its quantitative characteristic. Emotional knowledge has got two dimensions: an extensive dimension that is quantitative, and an intensive dimension that is qualitative. By analogy with thermodynamics, we may call the intensive property *emotional temperature*.



**Fig. 3** Thermal energy metaphor structure

It is interesting to underline the fact that the same emotion may have different temperature values for different people, and different emotions may have different temperature values for the same individual. However, at this stage of research we do not know how to measure the emotional temperature, but that is not an argument for not considering this new dimension of knowledge. We have to remember the fact that even the temperature of a body immersed in a thermal field could not be measured in the beginning. It took some time for scientists to develop the thermometer as a practical instrument of measuring the temperature of a body.

Finding a similar instrument and method to measure the intensity of a certain emotion is just a challenge at this moment.

In figure 3 we illustrate the structure of the thermal energy metaphor for knowledge. In this metaphor we change the mechanical perspective for the thermodynamics perspective. In the energy domain we consider two forms of energy: mechanical energy (ME), and thermal energy (TE). Energy can be transformed from one form into another form in concordance with the second law of thermodynamics. In the knowledge domain we consider two forms of knowledge: cognitive knowledge (CK), and emotional knowledge (EK). As a result of this metaphor, we may consider that cognitive knowledge can be transformed into emotional knowledge and vice versa. This is an important result of our analysis since it reveals new aspects of knowledge dynamics, which could not be seen in the previous metaphors. Actually, this transformation of cognitive knowledge into emotional knowledge and vice versa is so spectacular that some people cannot understand and accept it. For many of them that is a pure speculation. However, many scientific discoveries and theories started as pure speculations.

The metaphor illustrated in figure 3 is a complex one, containing actually four interacting metaphors:

- Metaphor #1: Knowledge as Energy.
- Metaphor #2: Cognitive knowledge as Mechanical energy.
- Metaphor #3: Emotional knowledge as thermal energy.
- Metaphor #4: Knowledge dynamics as energy thermodynamics.

The last two metaphors are completely new by comparison with any other metaphor developed so far. The thermodynamic approach opens new windows of understanding of knowledge and its dynamics, such as knowledge management, can be much more effective. Now we can understand much better why emotional knowledge plays such an important role in decision making. As Hill remarks, "*Breakthrough in brain science have revealed that people are primarily emotional decision makers*" [31, p. 2].

#### 4. CONCLUSIONS

The purpose of this paper is to develop a new type of metaphors for understanding the concept of *knowledge* based on thermodynamics principles. That means to go beyond the Newtonian mechanics, where knowledge has been interpreted as a stock or a flow, which means tangible objects. Also, to go beyond the linear metrics applied to the tangible resources and to accept that one of the most important characteristics of knowledge is the

property of non-linearity. That means to think in terms of synergy, when the result of interaction of several elements within a system is higher than their arithmetic sum. Synergy is very important in management and leadership since they are domains where motivating people is essential, and where organizational knowledge and intelligence is not a result of summing up the knowledge and intelligence of all employees.

In order to deal with these managerial processes it is necessary to find new metaphors for knowledge, going beyond that of *stocks and flows*, which is mostly used today. Stocks reflect accumulation of knowledge like accumulation of water in a certain reservoir, and flows suggesting the transfer and sharing of knowledge within an organization.

The first advantage of using energy metaphors for knowledge is that of interpreting knowledge as a field of forces, and no longer as a mere substance. This new paradigm allows us to develop a new theory of knowledge dynamics based on the multifield structure of the organizational knowledge. We may consider that in any organization there are several fields of knowledge, the most important being: cognitive knowledge, emotional knowledge, and spiritual knowledge. Cognitive knowledge represents rational knowledge and it is important in working with analytics and sets of data. Emotional knowledge reflects the feelings and emotions of employees, in different working contexts. Their motivation is essential in creating new knowledge and in realizing a competitive advantage of the company on the market. Spiritual knowledge reflects the individual and organizational values. Although we discussed only about cognitive and emotional knowledge in our metaphors, spiritual knowledge plays a guiding role in the process of decision making.

The most important contribution of the energy metaphors comes from the dynamics transfer from the energy domain towards the source domain. This dynamics reflects the possibility of transforming one form of knowledge into another form of knowledge, a feature that other metaphors do not have so far. This transformation can explain how people make decisions, especially when they act as customers. Many decisions are completely irrational due to the powerful influence of emotions, and they cannot be explained based on the known linear and rational metaphors used so far in economics and management.

Finally, the energy metaphors and the law of entropy open new directions of research for knowledge management and intellectual capital management in organizations.

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