The Theory of Infoledge: A Logical, Mathematical, and Geometrical Interpretation

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Abstract

This paper presents a logical, mathematical and geometrical interpretation of the previously presented term, infoledge. There is a strong relationship between the infoledge concept and complex numbers, which is utilized by the researchers in the mathematical interpretation of the infoledge concept. Autopoietic theory skeleton is the starting point in the current paper. Further more, the physical concepts, namely, kinematics and dynamics are introduced utilizing the cognition based concepts and certain concepts like domain and space. The current interpretation is expected to help in knowledge transfer simulation, cognition and recognition, artificial intelligence developing tools efforts. It is expected that the findings will enhance the relevant literature and applications.

Keywords: autopoietic theory, imaginary numbers, complex numbers, cognition, infoledge, knowledge transfer.

Introduction

Knowledge transfer questions: how, what and who energize the interest of researchers to revise the road map from information to knowledge, where the goals and interests definitely differ. According to Boisot and Griffith (2001) defined information as the meaning that is related to an **observer's** prior expectation when it is extracted from incoming data, where knowledge is the individual interpretation of the meaning of information that modifies the individual beliefs that reside in him. Information viewed as a message is meant to shape up the individual that gets it, to make some difference in his prospect and insight and it only becomes knowledge when it conveys meaning for the receiver. Davenport and Prusak (1998, p. 5) define knowledge as a fluid mix of framed experience, contextual information, values and expert insight that provides a framework for evaluating and incorporating new experiences and information. Achterbergh and Vriens (2002) stated that to determine whether a signal is informative, an observer has to append meaning to it, e.g., to perceive and interpret it. Once perceived and interpreted the observer may evaluate whether the signal is informative. It is essential to identify the observer according to our current discussion; however, as a primary entrance to the observer it is crucial to have quick and brief look at autopoietic theory.

Autopoietic Theory

Autopoietic theory considers the dynamics of living systems. The process called 'Autopoiesis' lies at the heart of this theory tries to detain the invariant attributes of living systems. Under Autopoietic theory, features like knowledge and beliefs arise in the domain of the observer, where someone watching a system interacts with its environment in such a way as to prompt the use of such terms. According to Koskinena, Pihlantob, and Vanharantaa (2003) autopoietic epistemology provides a fundamentally different understanding of the input coming from outside an organization. Input is regarded not as knowledge but as data, i.e. knowledge is data put into a certain context. This means that knowledge cannot be directly conveyed as knowledge from one individual to another, because data have to be interpreted –see Figures 1 and 3. Also, it was declared by that knowledge is a component of the autopoietic, i.e. self-productive process. This means that knowledge context dependent and situation sensitive (Maturana & Varela, 1987; Varela, Thompson, & Rosch, 1991).

According to Vicari and Troilo (1999) the only way to acquire new knowledge is to utilize existing knowledge since knowledge cannot be transmitted but only produced.

The Observer

The nervous system recursively interrelate its components leading the organism to generate, maintain and re-engage its own states as if they were literal re-presentations of external phenomena. Such states are 'second-order' in the sense that they are derivative from experience. These states are called **descriptions** in autopoietic theory, and an organism operating within the realm of its descriptions is an **observer**. 'An observer is a ... living system who can make distinctions and specify that which he or she distinguishes as a unity, as an entity different from himself or herself that can be used for manipulations or descriptions in interactions with other observers.' (Maturana, 1978, p. 31). The observer is one of the key concepts in autopoietic theory, because: 'Observing is both the eventual starting point and the most basic question in any effort to **comprehend** reality and reason as phenomena of the human domain. Indeed, everything said is said by an observer to another observer that could be him- or herself (Maturana, 1988, p. 27).

Data-Wisdom Conversion Spectrum

Autopoietic systems are both closed and open. Open to data, but closed to information and knowledge, both of which have to be interpreted inside the system where input is regarded as data only. The world is constructed within the system and it is therefore not possible to “represent” reality. Knowledge is private, and is thus accumulated within the system. Alkhaldi (2005), Alkhaldi and Olaimat (2006) presented a methodical process (see Figures 1 and 3), where they indicated that once knowledge articulation is started by the knowledge owner (sender), data will start to be accumulated and mounted by the knowledge recipient (receiver). While the knowledge owner continues the articulation process, the recipient keeps adding meaning (reflect) to the previous concept obtained thereby converting it into direction. By this stage, the infoledge will be conceived, which is, in simple terms, information with direction (Meta information).

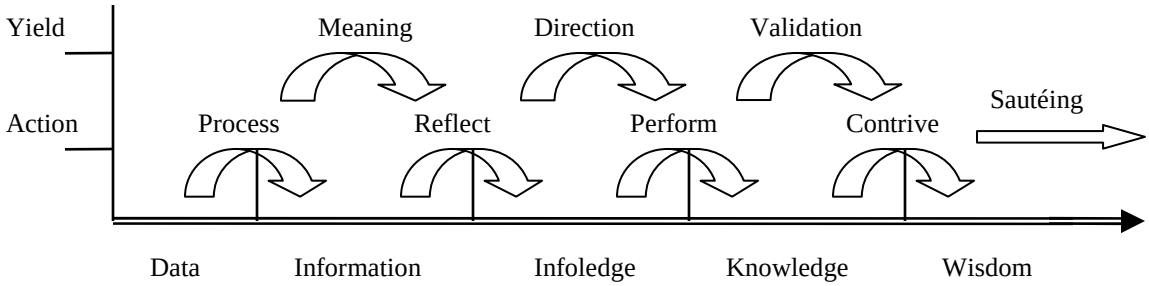

Figure 1: Data-wisdom conversion spectrum (Adapted from Alkhaldi, 2005)

Mathematical Interpretation: Definitions (Salas, 1998)

Definition 1: Complex numbers

Any complex number, *z*, can be written as

$$Z=X+iY \qquad (0)$$

Where *X* and *Y* are real numbers and *i* is the imaginary unit, which has the defined property that:

$$i^2 = -1$$

The number *X*, defined by

$$X=Re(Z)$$

Is the real part of the complex number, *Z*, and *Y*, defined by

$$Y=im(Z)$$

is the imaginary part. The term "imaginary number" usually means a complex number with a real part equal to 0, that is, a number of the form *iY*. Zero (0) is the only number that is both real and imaginary.

Definition 2:

By definition, the imaginary unit *i* is one solution of the quadratic equation

$$X^2+1=0$$

Or equivalently

$$X^2 = -1$$

Since there is no **real** number that squares to any negative real number, we *imagine* such a number and assign to it the symbol *i*. Real number operations can be extended to imaginary and complex numbers by treating *i* as an unknown quantity while manipulating an expression, and then using the definition to replace occurrences of i^2 with −1.

Geometric Interpretation

Geometrically, imaginary numbers are found on the vertical axis of the complex number plane, allowing them to be presented orthogonal to the real axis. One way of viewing imaginary num-

bers is to consider a standard number line, positively increasing in magnitude to the right, and negatively increasing in magnitude to the left. At 0 on this *x*-axis, draw a *y*-axis with "positive" direction going up; "positive" imaginary numbers then "increase" in magnitude upwards, and "negative" imaginary numbers "decrease" in magnitude downwards. This vertical axis is often called the "imaginary axis" and is denoted ***iR***.

In this model, multiplication by − 1 corresponds to a rotation of 180 degrees about the origin. Multiplication by *i* corresponds to a 90-degree rotation in the "positive" direction (i.e. counter-clockwise), and the equation $i^2 = -1$ is interpreted as saying that if we apply 2 *90-degree rotations about the origin, the net result is a single 180-degree rotation. Note that a 90-degree rotation in the "negative" direction (i.e. clockwise) also satisfies this interpretation. This reflects the fact that − *i* also solves the equation $x^2 = -1$ (See Figure 2).

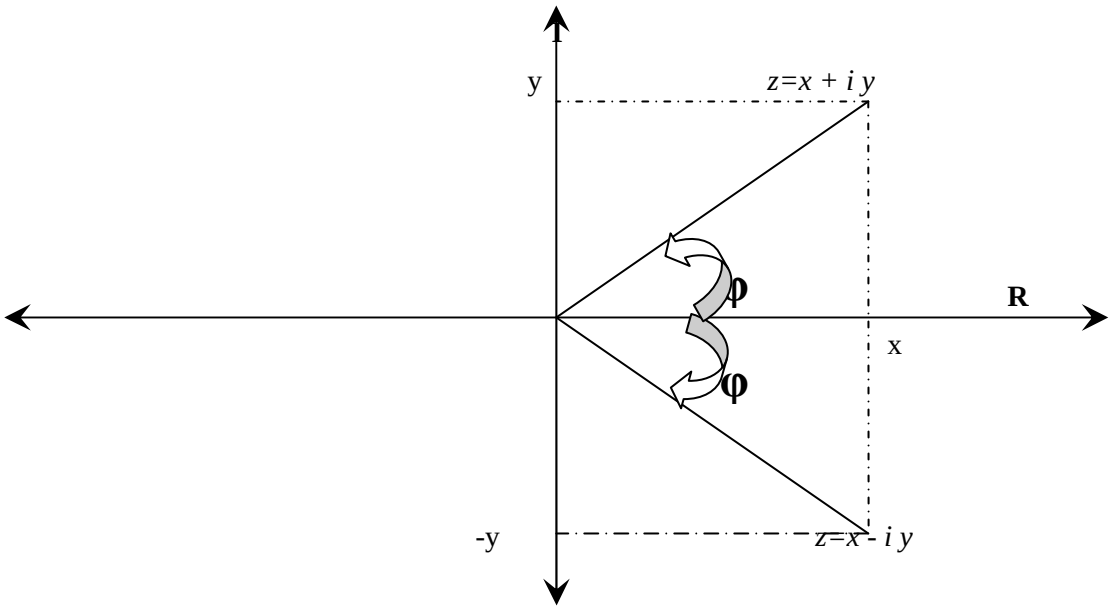

Figure (2): Complex numbers plane.

Imaginary Numbers and Real World

Imaginary numbers exist in the context of a different number system, namely, the "complex numbers".

Enlightening Analogies

Fractions: Consider the fractions, they are pairs of numbers. They can measure "how much" in some contexts (for example, "I ate three quarters of an apple"). So, the principle of considering a pair of numbers (in this example, 3 and 4) as a number in its own right is entrenched. An imaginary number could not be used as a measurement of how much money one has, or how many pages in the book. Even so, there are a few real world quantities for which complex numbers are the natural model. The following analogy demonstrates this idea. Questionnaire is distributed among a certain population. This population includes 800 respondents: 226 managers, 324 customers and 50 are public relationships employees. These figures imply that 28.25% are managers, 40.5% are customers and 6.25% are public relationships employees. This argument has used *fractions*, non-integer numbers, in a problem where they have no physical relevance! You can't measure populations in fractions; you can't have "0.25 person", for example. The kind of numbers that

have direct relevance to measuring numbers of people are the natural numbers; fractions are just as foreign to this context as the complex numbers are foreign to most real-world measurements. Yet, despite this, allowing ourselves to move from the natural numbers to the larger set of rational numbers enabled us to deduce something about the real world situation, even though measurements in that particular real world situation only involve natural numbers.

Electromagnetic field: The magnetic field has both an electric and a magnetic component, so it takes a pair of real numbers (one for the intensity of the electric field, one for the intensity of the magnetic field) to express the field strength. This pair of real numbers can be thought of as a complex number, and it turns out that the strange rule of multiplication of complex numbers has relevance to the physics of an electromagnetic field. Many properties related to real numbers only become clear when the real numbers are thought of as sitting inside the complex number system. Therefore, complex numbers aid in the understanding even of things that are described by real numbers.

Shadow: The shadow lives in a two-dimensional world, so only two-dimensional concepts are directly applicable to it. However, thinking of the three-dimensional object casting the shadow can aid in understanding it, even though three-dimensional concepts don't have any direct application to the two-dimensional world of the shadow. Likewise, complex numbers may not be directly applicable to a real world measurement any more than a three-dimensional object is directly applicable to a 2-dimensional shadow, but they can still help us understand it.

Quadratic polynomial* ($P(x) = a x^2 + b x + c$)*:* One very often has to solve the above equation by finding its zeros. This quadratic polynomial has two zeros: r1 = ([-b ± SQRT ($b^2 - 4ac$)] ⁄ 2a) , where SQRT denotes to square root. If b2 – $4ac$ < 0, then the zeros of the quadratic polynomial ***P* are not real numbers. However, in the complex numbers there are, so one can find all complex-valued solutions to the quadratic polynomial, and then finally restrict oneself to those that are purely real-valued. The starting and ending points of the argument involve only real numbers, but one can't get from the start to the end without going through the complex numbers. In mathematics, the **imaginary unit *i*** allow the real number system ***R*** to be extended to the complex number system ***C***. Its precise definition is dependent upon the particular method of extension. The primary motivation for this extension is the fact that not every polynomial equation $P(x) = 0$ has a solution in the real numbers. In particular, the equation $x^2 + 1 = 0$ has no real solution. However, if we allow complex numbers as solutions, then this equation, and indeed *every* polynomial equation $P(x) = 0$ does have a solution.

Intuition Concept

Intuition represents the way how the human view certain concept, but this process (view formulation) depends on the base knowledge “mental framework” (Please refer to Definition1) within human mind toward this concept, which is what we call the tacit knowledge related to this concept .Thus intuition is a critical part of knowledge, and according to Alkhaldi (2003) intuition provides speed since it allows the knower to deal quickly with new situation and he does not need to relearn the aspect of a new situation. According to Alkhaldi and Olaimat (2006):

- Human intuition for certain situation is the net resultant of a group of related tacit knowledge.
- Time plays a vital role in determining intuition since it is a maturing process related to the accumulating of tacit knowledge during many periods of times.
- As tacit knowledge increases, the intuition gets closer to the exact meaning. This stage is called wisdom.
- Intuition is changing frequently due to its ingredients.

Based on the above discussion, it appears that learning impact has the main role in building intuition. The above results are supported by Jamieson and Hyland (2006) who state that decision makers apply cognitive filters or biases to simplify the decision making process. In the above discussion it was indicated that the organism is capable of generating, maintaining and re-engaging its own states as if they were literal re-presentations of external phenomena. These states were considered in autopoietic theory as being derivative from experience. The relation between the last argument, i.e, derivative / experience concepts from one side and imaginary/real in complex systems on the other side is clear, namely, the imaginary part is related to derivative side, on the other hand, real one is related to experience (nearly fixed perception toward a certain concept/entity).

Knowledge Transition Stages

According to Alkhaldi and Olaimat (2006) explicit knowledge can be represented mathematically by the following expression:

Lim intuition = Explicit knowledge…….. Eq (1)

$t \rightarrow 0^-$ (The minus sign is for the left direction, definition 2)

In it higher completeness stage, explicit knowledge articulated by the owner can be seen as Infoledge by the receiver. In another words, after knowledge articulation by the sender (real part) and before knowledge comprehension (validating) by the receiver (imaginary part), Infoledge materializes. At this stage the knowledge needs to be extorted from one context and be converted and adapted to another context. The adaptability depends on the way how this context will be interpreted, which means the way how both real part and imaginary part are interrelated. The researchers call it Infoledge due to its different views according to sender and receiver, in other words due to the imaginary part of the infoledge forming equation. To elaborate more, Infoledge emerges as the sender passes information through the knowledge space to the receiver. To the sender it is his/her Knowledge (explicit knowledge) that he/she was able to articulate through language or other communication means. To the receiver it is information with direction that has not been experienced, tested, or lived by him/her, and yet it cannot be classified as knowledge (since the imaginary part is still growing). The reason the researchers called it infoledge is the fact it is extracted out of the concept of doing, where knowledge by fact requires doing to be comprehended. At the end of externalization stage, the **sender** expresses his/her knowledge (remember, the term "imaginary number" usually means a complex number with a real part equal to 0) and the receiver obtains a full meaning statement, which is known as information or infoledge given the absorptive capacity of the receiver and its location on the data-wisdom spectrum see figure 1, 3. Then the flow of infoledge messages drive the receiver to start his processing according to the base knowledge (mental frame work), consequently, the **imaginary part** starts to be shaped at the receiver side. Up to now we've seen that imaginary part of any dialogue exist (like imaginary numbers exist) and it exist in the context of infoledge system (like complex numbers).

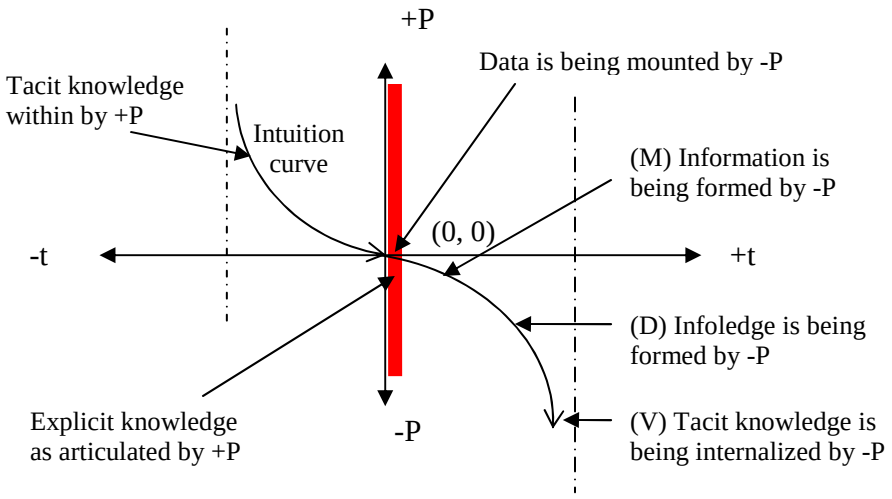

Figure 3: Overall conversion knowledge process.
(Adapted from Alkhaldi and Olaimat, 2006)

Again we will go back to the understandability conception, which was expressed mathematically by Alkhaldi and Olaimat (2006) as follows:

Understandability $\propto$ [1 / Complexity], where $\propto$ denotes to proportional relationship.

Where the complexity is strongly related to the knowledge type (the level of envision), i.e., trivial knowledge, base knowledge. As the complexity increases, the understandability will decrease, i.e, as the imaginary part role increases the complexity increase. This role emerges at the receiver side where he/she start shape his view toward the new concept. Maqsood et al. (2004) asserted that the first element involved in the human information process is the progress of knowledge creation of the perception of the event, and then the use of memory to give this perception recognition, they maintained that perception is affected by factors such as attitudes, values, stress and a person's background. Taking into consideration the above definitions and arguments then we can define the following:

Infoledge = Real part +Imaginary part …….. (2)

It is clear that real part is the information getting out of the sender and get in the receiver side, but what about the imaginary part? How can this imaginary part be defined? From the previous discussion it can be inferred that the imaginary part is not limited with fixed weight, but this weight change according to the input, i.e.; the information. However, there is some thing bounded to certain limit and the receiver tries to build his hidden thoughts on it, i.e, his tacit toward certain concept. Now let us examine the relation between the tacit toward certain concept and the role of the new information flow according to the receiver. It is clear that as the information flow increase the imaginary part increase, mathematically:

Imaginary part $\propto$ information flow outcome, : for proportionality.

Imaginary part = constant X information flow outcome, X: multiplication symbol.

Information flow outcome: is the new imagining margin of him receiver which is flexible until the new tacit is formed, i.e. when the complete information meaning is gotten, consequently:

Imaginary part = bXi

Where

b: the tacitness capability of the receiver.

i: the imagining capability of the receiver.

And then equation (2) becomes:

Infoledge = information +Imaginary part

Infoledge = a+bi …….. (3)

And this is the formula that can be actually express infoledge nature, i.e. complex concept is enlightened by complex number theory. At the sender side where imaginary part is not exist and the formula become:

Information =*a*, which is the real part of equation (3); please refer to definition (1).

Referring to Figure 2 the x-axis denotes to the real part of equation (0), on the other hand y-axis denotes to the imaginary part of it. However the real part is not directional quantity, so the direction is to the imaginary part and the angle (φ) represents the way how the real part affect the accumulation of imaginary one. The previous discussion supports the researcher's view of infoledge as a system.

More Elaboration

Now, until this moment it is obvious that the imaginary part is the result of an individual tacitness and imagination capability. The thing to be guaranteed is that the tacitness of the receiver at the moment of initiating infoledge can be considered constant. When the infoledge starts flowing toward the receiver, the cognition/recognition processing begin, which imitate the physical resistance to the current flow in the electrical engineering world. **We argue that the imaginary part of infoledge is power** increase or decrease with the two variables i.e. tacitness and imagining capability.

Mathematically this can be accepted if we know that the real part of equation 2 i.e. the information has static nature. Based on the previous discussions we have to point to the idea that our progress is toward viewing the kinematics' and dynamic world within knowledge conversion process which will be the focus of upcoming research by the authors. To elaborate more: physically the kinematics science deal with the movement of things while dynamic deal with the forces causes these movements. In the following section the kinematics and dynamics concepts will be enlightened through cognition based argument.

Cognition

According to Maturana and Varela (1980), cognition is dependent on embodiment, because this ability to differentiate is a consequence of the organism's specific structure - which is kinematical view-. From their perspective, cognition is what we attribute to systems exhibiting flexible and effective changes during structural coupling which is dynamical view. Cognition in the autopoietic view is no more and no less than a living system's effective behavior (kinematics) within its domain of interactions (dynamic). 'Living systems are cognitive systems, and living can be seen as a process is a process of cognition.' (Maturana & Varela, 1980, p. 13) For the purpose of the above argument, it must suffice to say that the reinterpretation of cognition grounds cognitive activity in the embodiment of the actor (dynamical view) and the specific context of activity (kinematical view). A key concept in Maturana and Varela's writings is **domain**. They use the term generally to mean a 'realm' or 'sphere' limits: (1) the relations among observed systems and the unities (medium) with which they can be observed to engage (e.g., phenomenological domain) or

(2) the foregoing plus all potential states of relation and/or activity among the given unities (e.g., domain of interactions). Maturana and Varela reserve the term **space** for the static context in which unities are delineated. It is obvious that the domain point to the dynamical view point, on the other hand space point to kinematical one. Finally, infoledge is a power that enhances tacitness of the being through extending the imagination role.

Conclusion

A logical, mathematical and geometrical interpretation of "infoledge" term was presented throughout this paper, starting with autopoietic theory skeleton, passing through complex and imaginary numbers, physical world ending with the cognition concept. The imaginary numbers exist and they serve a solution to many real and renewable problems, so this category of numbers was utilized to illustrate infoledge. All through in this paper the authors invoke to express infoledge as a system by comparing it with complex numbers system. In addition, the physical concepts, namely, kinematics and dynamics were linked with the study goals leading the final result, i.e, infoledge is a power that enhances tacitness of the being through extending the imagination role.

Contribution to Knowledge

It is expected that the above interpretation will help in knowledge transfer simulation, cognition and recognition, artificial intelligence developing tools efforts. Furthermore, the above interpretation will enhance the researches efforts in organizational learning and knowledge retrieval where the stickiness of firms' cultures will be the core interest, leading to build more proper knowledge management strategies. Also, it is expected that the researches concerning uncertainty types; i.e, acquiring information, coordination and motivation will effectively utilize the findings of this paper. Moreover, the health sector can utilize the imitation made through out the paper especially in the special affairs people through getting closer to their needs.

References

Achterbergh, J., & Vriens, D. (2002). Managing viable knowledge. *System Research and Behavioral Science, 19*, 223.

Alkhaldi, F. M. (2005). *Spectrum of knowledge conversion: The theory of "Infoledge"*. Unpublished Manuscript, Arab Academy for Banking and Financial Science, Amman, Jordan.

Alkhaldi, F. M. (2003). *An integration of information technology, culture of knowledge transfer and innovative work environment in support of organisational knowledge creation activities*. Unpublished PhD, University of Huddersfield, UK

Alkhaldi, F. M., & Olaimat, M. M. (2006).Knowledge Conversion and Transfer: A Mathematical Interpretation. *Interdisciplinary Journal of Information, Knowledge, and Management*, *1*,137-149. Retrieved from http://ijikm.org/Volume1/IJIKMv1p137-149Alkhaldi.pdf

Boisot, M., & Griffith, D. (2001). To own or to possess? Competence and the challenge of appropriability. In R. Sanchez (Ed.), *Knowledge management and the organizational competence* (pp.210-226). London: Oxford University Press.

Davenport T., & Prusak, L. (1998). *Working knowledge*. Boston, MA: Harvard Business School Press.

Jamieson, K., & Hyland, P. (2006). Good intuition or fear and uncertainty: The effect of bias on information systems selection decisions. *Informing Science Journal, 9*, 49-68. Available at http://inform.nu/Articles/Vol9/v9p049-069Jamieson60.pdf

Koskinena, K. U., Pihlantob, K., & Vanharantaa, H.. (2003). Tacit knowledge acquisition and sharing in a project work context. *International Journal of Project Management, 21*, 281–290

Maqsood, T., Finegan, A. D., & Walker, D.H. (2004). Biases and heuristics in judgment and decision making: The dark side of tacit knowledge. *Issues in Informing Science and Information Technology, 1*, 295-301. Available at http://articles.iisit.org/050maqso.pdf

Maturana, H. R. (1978). Biology of language: The epistemology of reality. In G. A. Miller & E. Lenneberg (Eds.), *Psychology and biology of language and thought: Essays in honor of Eric Lenneberg* (pp. 27-63). Academic Press.

Maturana, H. (1988).Reality: The search for objectivity or the quest for a compelling argument**.** *The Irish Journal of Psychology, 9*(1), 25-82.

Maturana, H., & Varela, F. J. (1980). *Autopoiesis and cognition: The realization of the living*. R. S. Cohen & M.W. Wartofsky (Eds.), Boston Studies in the Philosophy of Science (Vol.42). Dordecht, Holland: D. Reidel Publishing.

Maturana, H. R., &Varela, F. J. (1987). *The tree of knowledge*. Boston: Shambhala.

Salas, S. L., & Etgen, G. J. (1998). Salas and Hille's calculus: One and several variables (8th ed.). John Wiley &Sons.

Varela, F., Thompson, E., & Rosch, E. (1991).*Embodied mind: Cognitive science and human experience.* Cambridge: MIT Press.

Vicari, S., &Troilo, G. (1999).Organizational creativity: A new perspective from cognitive systems theory. In G. von Krogh, I. Nonaka, & T. Nishiguchi (Eds.), *Knowledge creation. A source of value*. London: Macmillan Press.

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