

# Perspectives on knowledge management models

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## **Abstract**

The purpose of this paper is to present the way some widely used knowledge management models are structured. We will describe the most important characteristics of each model, with our comments about its usefulness in the economical environment. The models we chose to analyze are as follow: von Krogh and Roos, Nonaka/Takeuchi, Wiig, Boisot and Bennet. We will discuss about main factors involved, about types of knowledge and elements which forms it and of course about advantages and disadvantages of these models. The paper will end with a general conclusion, which will largely synthesize our conclusions about each knowledge model

**Keywords:** knowledge, model, cognitive, epistemological, tacit, explicit, internalization, adaptive, assets, efficiency, forecasts, measures, dimensions

## **1. Introduction**

If we are looking from a practical perspective, knowledge management requires certain organizing principles – a general framework – which will help us to classify different activities types and functions, which are needed to the work implying knowledge, both inside and outside of an organization. These general frameworks are to be found in form of theories and models for knowledge management. We can find in the specialized literature many models regarding knowledge management. From all these models we identified certain models that we think can be very well applied in almost any type of economical organization.

The choice we have made was based on the identification and analysis of many perspectives regarding basic concepts. Our purpose is to bring contrast, by comparing each model, in order to refine a better view over knowledge management processes. All selected models that will be described further on presents the following important characteristics:

- ✚ are able to realize a complete approach over knowledge management, they take in consideration people, processes, organization as a whole, technological dimensions
- ✚ were analyzed/discussed in knowledge management literature by academic researchers and business people
- ✚ all models were implemented and tested regarding reliability and validity

Of course, our analysis it is not supposed to be an exhaustive one, but we think that the selected models will enlarge the perspective over knowledge management and the benefits it can bring.

## 2. Insights on knowledge management models

### 2.1 Von Krogh and Roos model

This model brings a clear distinction between individual knowledge and social knowledge, following an epistemological point of view regarding knowledge management. According to this model, the following aspects should be analyzed:

- why and how the knowledge gets to the employees of a company
- why and how the knowledge reaches the organization
- what does it mean knowledge for the employee/organization
- what are the barriers for organizational knowledge management

The cognitive perspective states that a cognitive system, no matter if it's human or artificial, creates representations (models) of the reality, and the process of learning appears when these representations are somehow manipulated (used in different inferences).

A cognitive epistemology sees organizational knowledge as a system with self-organization characteristics, where people are transparent to the information coming from the exterior (we obtain information through senses and we are using it in order to create mental models)<sup>62</sup>. In this perspective, the brain can be perceived as a machine based on logic and detections, which doesn't permit opposite declarations. So, the organization gathers information from its environment, which it processes logically. By searches and different cognitive competencies, possible ways of actions will be generated – everything is based on the mobilization of individual cognitive resources.

It is known that the brain is not processing sequential symbols, but rather it perceives the whole perspective, global properties, models and synergies. Learning rules are those which can govern how the different components are inter-related. The information it is not just taken from the exterior environment, it can be generated also internally. The familiarity and practice are leading to learning. The employees form nodes of an organization's system, with relative weak links – knowledge represents an emergent phenomenon which comes from the social interaction of these persons.

We emphasize a very important conclusion: Knowledge is not present only in the mind of the people, but also in the connections (links) between them. As a representation of this network, the collective mind will be formed, which represents the core of organizational knowledge management.

Von Krogh and Roos are following in their models the principles of a connectionist approach. In their organizational model, the knowledge is to be found both in the mind of the people and in the connections between them.

Compared to the cognitive approach, which sees knowledge as an abstract entity, a connectionist idea states that it is impossible to have knowledge without a knower. This is very well fit on the concept of tacit knowledge, which are very difficult to abstract. Krogh and Roos examined the nature of knowledge management from the perspective of: employees, communication, organizational structure, links between members and management of human resources<sup>63</sup>. These five factors can generate problems which can prevent knowledge management strategies. For

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<sup>62</sup> Von Krogh, Nonaka I.: "Enabling knowledge creation: how to unlock the mystery of tacit knowledge and release the power of innovation", Oxford University Press, 2000

<sup>63</sup> Von Krogh, Roos, J.: "Knowing in firms: understanding, managing and measuring knowledge", Sage Publications, London, 1998

example, if the employees are not perceiving the knowledge as being an important part of the company, the effects will be seen in their quality of work. Also, if there is no common language to express new knowledge, keeping this new knowledge will be very difficult. In the case where members of the organization are not willing to share their experiences, it will be extremely difficult to generate social collective knowledge. Companies should use elements which activates knowledge by the stimulation of the employees.

This approach was further refined to identify a model for „knowledge activation”, before starting a knowledge management program. Activation refers to the general set of organizational activities which positively affects knowledge creation. These activities can highly improve human relationships, conversations and sharing local knowledge. We can say that connexionist approach seems to be a good base for a theoretical knowledge management model, mainly because of the fact that the link between knowledge and the ones who posses it, seems to be permanent.

## 2.2 „Nonaka - Takeuchi” model

This model was obtained after the research regarding the success of some Japanese corporations, about obtaining creativity and innovation. They discovered that this success didn't come from a mechanical processing of some objective knowledge, but from elements extremely subjective (metaphors and symbols).

The two researchers mention that a key factor of Japanese companies comes from the approach oriented much more to tacit knowledge. West cultures consider the knower and the element which is known as separate entities. In contrast, oriental culture believes in unity: mankind and nature, body and mind, own person and the others. In such an environment, knowledge is mainly found not at the individual but in groups, and it's easy to convert, shared and transferred. Nonaka and Takeuchi emphasize the necessity to integrate both kinds of cultures, in order to obtain better instruments. Knowledge creation begins always at the individual level.

Starting from this personal knowledge, mostly tacit, we will obtain organizational knowledge. The availability on every company level represents the essence of Nonaka model. Knowledge creation takes place as a continuum in all the compartments of the organization. According to Nonaka and Takeuchi model, there are four modes to convert knowledge, which represents „the engine” of the whole process to create knowledge<sup>64</sup>. The creation of organizational knowledge represents the amplification of individual knowledge and its transformation into general applied knowledge. Next figure presents the stages involved in the process of knowledge creation:

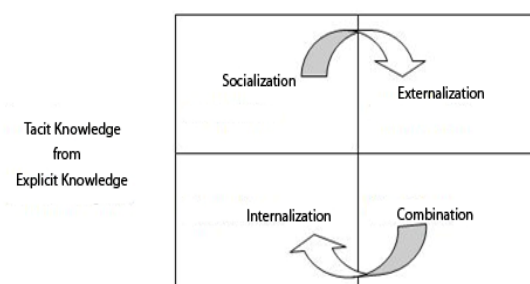


Figure 1: Knowledge conversion in Nonaka-Takeuchi model

<sup>64</sup> Nonaka, I, Takeuchi, H: “The knowledge creating company: how Japanese companies create the dynamics of innovation”, Oxford University Press, 1995

Socializations means to share knowledge by direct social interactions. Also, it implies to obtain a mutual understanding. It is one of the simplest forms of knowledge exchange, because it's an instinctual state. The greatest advantage of socialization it is also its greatest disadvantage, because knowledge remains tacit, it will be very rarely written or stored.

Davenport and Prusak emphasizes that: "Complex, tacit knowledge, developed and internalized by the one who posses it over a long period of time it is almost impossible to be reproduced in a document or in a database"<sup>65</sup>. Such kind of knowledge incorporates so many details that the rules which define it are impossible to be separated. This leads to the idea that the process of obtaining new tacit knowledge it is not strictly tied to language but rather to experience and the ability to transmit it. The externalization process offers a tangible form of tacit knowledge by converting it to explicit knowledge. The employees are capable to define knowledge structures and to use certain methods to apply it in specific circumstances. Once externalized, knowledge is tangible and permanent. It can be easily shared and spread in organization. We can at this moment to start using Content Management Systems, used to create, manage, update, search and publish electronic texts or any other digital media format. For further identification it is important not to lose information about knowledge creators during the conversion from tacit to explicit. Next phase of knowledge conversion it's represented by combination (explicit to explicit). We understand by combination the process to combine knowledge pieces in order to obtain new knowledge forms. There is no knowledge which it's created by itself – it represents a new combination or a representation of an existing knowledge. Thus, combination takes place when concepts are sorted and systematized in a knowledge system. Internalization represents the last stage of knowledge conversion (explicit to tacit). This is realized through the diffusion and involvement of the new understood behavior.

We can associate internalization with the process of learning by practice. This implies to convert or integrate our knowledge/experience in mental models which will extend it, eventually reformulate in the context of a different knowledge base. Knowledge, experiences, best practices, learned lessons are passing through the conversion process, but it is impossible to stop at an intermediary phase. Only when knowledge is internalized in the knowledge base according to some mental models which can be shared, it will become useful to the company. We make a short comment by mentioning that is necessary for knowledge creation that this process to be reiterated for several times. Tacit knowledge accumulated at individual level must be socialized with other members, generating this way a spiral, which describes knowledge creation – which we can say that it is not a sequential process.

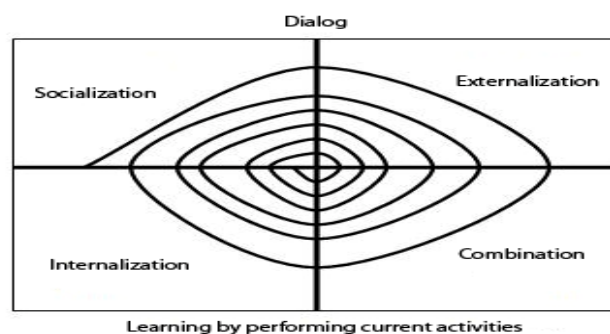


Figure 2: Nonaka/Takeuchi knowledge spiral

<sup>65</sup> Davenport, T, Laurence P.: "Working knowledge: how organizations manage what they know", Harvard Business Press, 2000

Figure 2 presents the way in which the organizations articulates, organize and systematize individual tacit knowledge. We consider that the most difficult steps in knowledge spiral are those which imply a change in knowledge type: externalization and internalization. We need ways to represent a consistent, systematic and logic understanding, without contradictions. Nonaka and Takeuchi describe the conditions which allow the creation of organizational knowledge<sup>66</sup>:

1. Intention: expressed by the organization will to fulfill its purposes (formulating strategies in business context)
2. Autonomy: the situation when individuals are acting autonomous, according to some minimum specifications, being implied in teams with self organizing capabilities
3. Fluctuations and creative chaos: specific condition which stimulates the interaction between the organization and the extern environment
4. Redundancy: the existence of information which exceeds the operational requests of organizational members
5. Variety: internal diversity which offers to every employee rapid access to a variety of information

### 2.3. "Choo" model

It is a very good model to manage knowledge based on elements used to create new senses for an optimized decision inference. Choo model centers on how informational elements are selected and introduced in company actions. This actions results from the concentration and absorption of information coming from the external environment in every cycle, illustrated in figure 3:

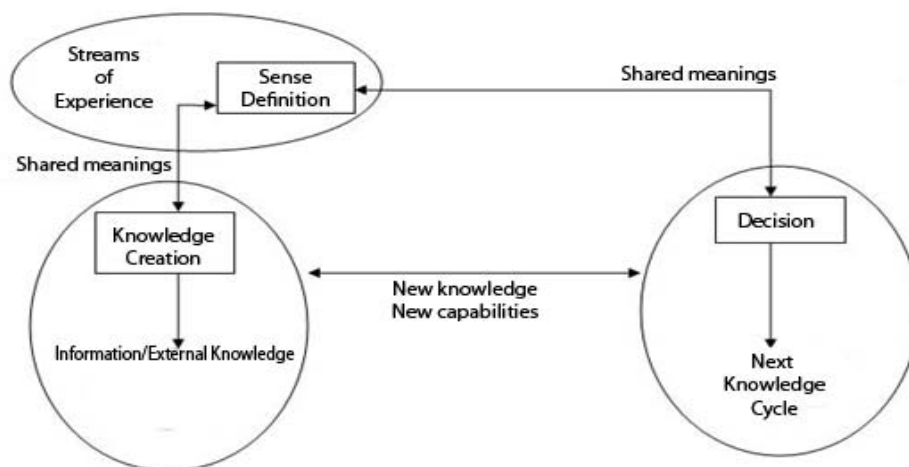


Figure 3: "Choo" knowledge management model

During the identification phase we will define priorities which are used for information filtering. At individual level, common interpretations will be built from the exchange of information pieces, combined with previous experiences. Weick proposed a theory where he tries to describe how chaos can be transformed in clear processes by sharing individual interpretations. We have identified four processes described by Choo model:

- ✚ *Changing the environment* - it is external for the organization, having the possibility to disturb information flow between participants
- ✚ *Adaptation*

<sup>66</sup> Sven, J, Henrik L.: "Intelligent management in the knowledge economy", Edward Elgar Publishing, 2003

- ✚ *Selection and keeping* - when people tries to interpret what have been observed. This is the process which refers the creation of organizational memory which will contain those experiences finalized with success. This memory can be reused in the future for new interpretations in order to unify them into a coherent organizational vision.

Knowledge creation can be perceived as a transformation of personal experiences into knowledge through dialog and sharing. Elements of this model can be found in important theories like: game theory, economic behavior and chaos theory. The capacity of human mind to formulate and solve complex problems it is quite small compared to the problem dimensions, of which solutions are necessary for a rational behavior. As a consequence, the persons who are confronted with ambiguous purposes and fuzzy methods to combine actions will try to fulfill those purposes which take a medium amount of time by using resources which are under their control<sup>67</sup>. Usually, when our mind is confronted with a world of great complexity, it will build a simple mental model and will act according to it. We found a strong element of Choo model in the holistic approach of key processes regarding knowledge management, with extension to decision areas, which often miss in knowledge management models.

## 2.4 „Wiig” model

The base of this model is represented by the following principle: „if we want to have useful and valuable knowledge”, these must be organized. Knowledge should be differently organized, accordingly to the way it will be used. For example, in our own mental models we have the tendency de deposit our knowledge using semantic networks. This model address also the problem referring to how relevant can be the knowledge, coming from a specific source. The source can be: minds of the people or knowledge bases (tacit or explicit). It is very important to know about knowledge that it is discoverable. Another important aspect refers to the relations between different objects of knowledge. We will find that very few elements are completely disconnected, in other words, independent. As a general rule we can say that content value is higher when we have a greater number of connections in a knowledge base. As a consequence, all the facts, concepts, perspectives, values, judgments must be consistent. We should try to reach a situation where there are no logical inconsistencies, internal conflicts or misunderstandings. Wiig model defines many levels regarding the internalization of knowledge. We present each level in the next table<sup>68</sup>:

*Table 1: Degrees of internalization in Wiig model*

Level	Type	Description
1	Novice	Extremely low consciousness (even not at all) about knowledge and the way it can be used
2	Beginner	He knows about knowledge existence and where it can be obtained, but he doesn't know the way it can be used
3	Competent	Knows, but the possibility of using knowledge is limited
4	Expert	He keeps the knowledge in mind, understands where can be applied, works with knowledge without extern intervention
5	Master	Completely internalization of knowledge; a master has a profound understanding about the events in his environment

<sup>67</sup> Choo C. : “The knowing organization”, New York, Oxford University Press, 1998

<sup>68</sup> Wiig, K: „People-focused knowledge management: how effective decision making leads to corporate success”, Butterworth-Heinemann, 2004



Internalization represents a continuous process, starting from the lowest level (the novice) where we don't know that we don't know to arrive at the master level, where we can find profound understanding of all concepts like „know-what”, „know-how”, „know-why”, „care-why” (values, judgments, motivations). We identify three knowledge forms: *Public* (explicit, can be learned and shared), *Sharing expertise* (intellectual assets which are held exclusively by employees and shared during work or embedded in technologies. This type of knowledge is usually communicated through a specialized language and representations), *Permanent knowledge* (the least accessible, but the most complete form of knowledge. It's usually tacit and used without knowing).

Besides these three forms, Wiig defines another four types of knowledge: based on facts, conceptual knowledge, methodological knowledge and expectation knowledge. Knowledge based on facts is about data, causal links, measures and readings – having an observable content, directly measurable.

Conceptual knowledge implies systems, concepts and perspectives. Methodological knowledge is used by strategies, methods for decision refining and other techniques. As example we find all the situations when the company is learning from previous mistakes or has the ability to make forecasts based on events analysis. Expectation knowledge refers to judgments, hypothesis and expectations of the persons that possess them. As examples, we can mention: intuitions, suppositions and heuristics that we are using in the process of taking decisions. All three classical forms of knowledge, combined with the perspectives proposed by Wiig, are forming a matrix which constitutes the core of Wiig knowledge management model (table 2)<sup>69</sup>.

Table 2: Wiig matrix

Knowledge form	Knowledge type			
	Facts	Concepts	Waiting	Methodological
Public	Measuring	Stability, Equilibrium	When stock value exceeds the request, the price drops	Searching for values in variables outside norms
Shared	Forecasts analysis	Heavy market	A small addition will not generate sell problems	The identification of some errors from the past
Personal	The value of the variable is the most suited	The company has very good references	The suspicion that an analyst made a mistake	What are the most recent tendencies

We consider that the important characteristic of this model is the fact that even if Wiig defined it in 1993, a very organized approach of knowledge types which can be managed makes from this model a very good theoretical model of knowledge management. Probably it represents the most pragmatic model, which we have in the present, which can fit easily on any other approach.

## 2.5 Boisot model

This model is based on the concept of „informational asset” which is different from a „physical asset”. Boisot made a distinction between information and data, emphasizing that information is what an observer will extract from data, according to his own experience and previous knowledge.

<sup>69</sup> Wiig, K.: “Knowledge management foundations: thinking about thinking. How people and organizations create, represent and use knowledge”, Schema Press, Arlington, 1993

The efficiency of informational assets transfer is largely dependent on senders and receivers, which have to share same codification scheme or language. Knowledge will also have a context in which it can be described<sup>70</sup>. Thus, it results that both the sender and receiver will have to share the context besides codification scheme. Boisot proposed three key points, which forms together a conceptual framework known as „i-space”. Boisot model („i-space”) can be visualized as a cube having the following dimensions: coded – “un-coded”, abstract – concrete, diffused – undiffused:

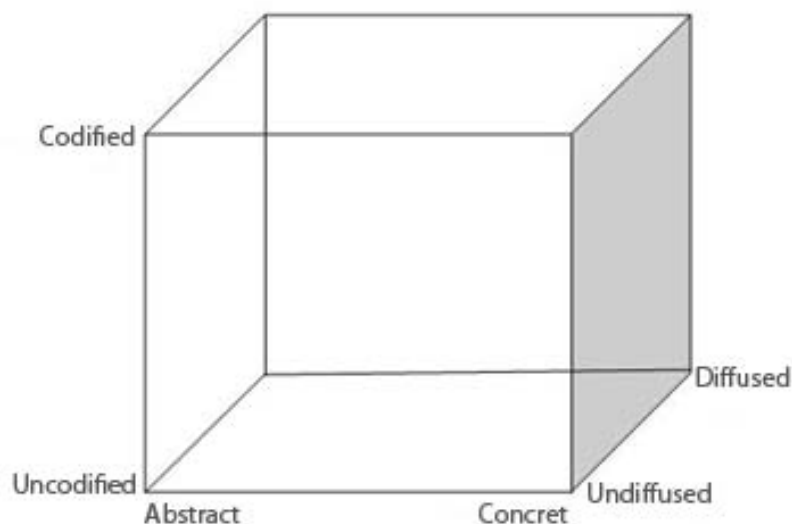


Figure 4: Boisot "I-Space" model

Data is structured and understood through different codification and abstract processes. Codification refers to the creation of some categories – lesser the number of categories, more abstract the codification scheme will be. Boisot model implies that in many situations the context loss because of the codification can lead also to the loss of important knowledge. This content needs a shared context in order to be interpreted and it requires face to face interactions (similar to socialization phase from Nonaka model). The activities of codification, abstractization, diffusion, absorption, impact and analysis, contributes to the learning process. No matter if it's sequential (and it's necessary to a certain point to be like this), together will form the six phases of a learning cycle.

We describe in table 3, these activities:

Table 3: "I-Space" model learning cycle

Phase	Name	Characteristics
1	Scanning	Identifying threats and opportunities from a fuzzy content Scanning, in the context of some models, for the discovery of new visions, which to become the possession of an individual or group. Scanning process can be fast when data is codified and abstract, or very slow and random when data is un-codified and dependent of context
2	Problem solving	The process which offers structure and coherence to these visions During this phase a large amount of uncertainty is eliminated Problem solving in the un-codified region of I-space model is often hazardous and conflict generating

<sup>70</sup> Boisot, M.: „Knowledge assets: securing competitive advantage in the information economy”, Oxford University Press, 1999



3	Abstraction	Generalization of applying new codified visions in a large number of applications It implies to reach the most important characteristics of a situation – conceptualization Problem solving and the abstracting often works together
4	Diffusion	Sharing new visions with a certain number of persons The diffusion of well codified abstract content to a large number of persons will be technically less problematic than the un-codified case and content dependent Only sharing context both by sender and receiver can increase the diffusion speed of un-codified knowledge
5	Absorption	Applying new codified visions to different situations, using a „learn by execution” manner Over time, codified visions will interact with those un-codified, the former one being favored in particular circumstances
6	Impact	Including knowledge in real practices Including knowledge in technical rules, organizational or organizational practices Absorption and impact often works in tandem

Thus, there is the potential to use Boisot model to manage knowledge assets of the organization according to learning cycle. Anyway, this model it is not very well known, so we couldn't find many implementations in the real environment.

## 2.6 Adaptive models of knowledge management

The ICAS (**I**ntelligent **C**omplex **A**daptive **S**ystems) theory sees organization as an adaptive, complex system. These models contain series of functions which ensures the viability of any living system in general and of organizations, in particular. ICAS systems are based on cybernetics principles, which are using communications and control mechanisms in order to understand, describe and predict what should do a viable organization. Adaptive systems contain lots of independent agents which are interacting. Their behavior makes possible the appearance of some complex phenomenons of adaptation. There is no general authority to manage the way in which these agents should work. A general model of a complex behavior will be the result of all the interactions.

Bennet describes an approach of knowledge management, using ICAS systems as a starting point. It is considered that traditional bureaucracies are not enough to provide the necessary cohesion for the survival of the organization. It was proposed a new model (Bennet) in which the organization is perceived as a system found in a symbiotic relation with its environment. Bennet model is based on a number of subsystems which interacts and evolves in order to generate an advanced and intelligent technological company<sup>71</sup>.

Inside the adaptive model, the intelligent components are made of people which are self organized, but who can remain as a part of general hierarchies of the organizations. The challenge is to use the advantage given by the force of the people when they cooperates, keeping a global sense of unity.

The organizations solve problems by creating options, using resources both internal and external which can add value over the initial input. So, the knowledge became the most valuable resource because it is the only one who can help in the context where uncertainty exists. This is one of the criteria by which we can distinguish between information

<sup>71</sup> Bennet, D: "Organizational survival in the new world: the intelligent complex adaptive system", Butterworth-Heinemann, 2004

management (predictable reactions to known situations and anticipated situations) from knowledge management (using new reactions for un-anticipated situations). We can resume key processes in Bennet model as being the following:

1. Understanding
2. Creation of new ideas
3. Problem solving
4. Decision taking
5. Following actions to obtain the desired results.

Because people can take final decisions and fulfill actions, this model emphasizes the importance of the person: competencies and learning capacity.

According to this model, in order to survive, an organization needs eight characteristics: organizational intelligence, shared purposes, selectivity, optimum complexity, open borders, knowledge centering, optimum streams and multidimensionality

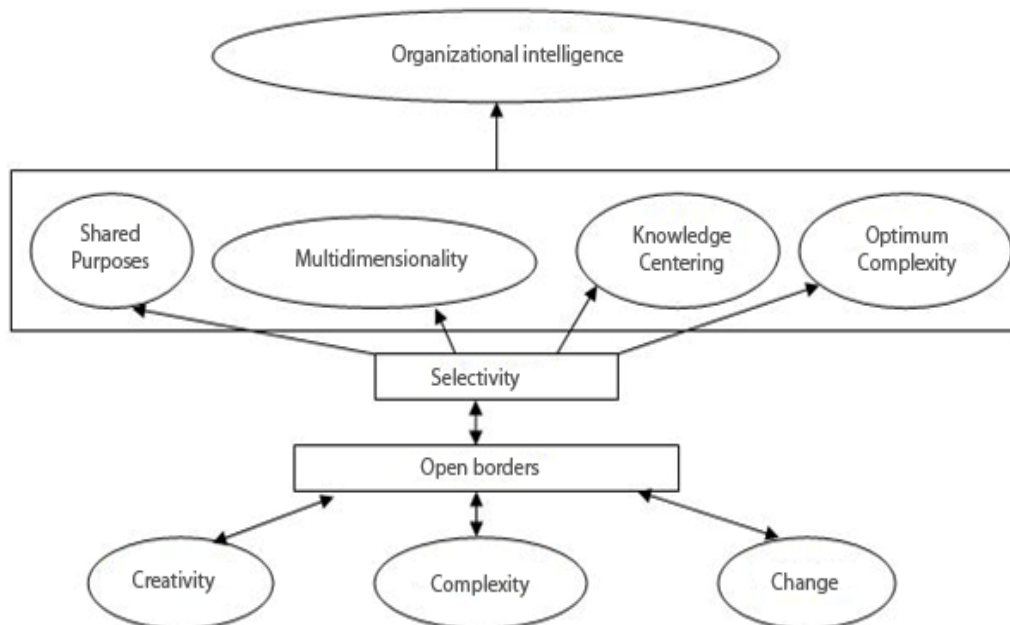


Figure 5: Bennet (ICAS) model

- ✚ The organizational intelligence represents the company capacity to innovate, to acquire knowledge and to apply it for relevant situations. In the context of ICAS models, this property reveals the capacity of the organization to perceive, interpret and respond to the environment in such a way that will allow reaching the desired purposes.
- ✚ Optimum complexity is represented by the correct equilibrium between internal complexity and external environment
- ✚ Selectivity refers to the content evolution, one characteristic that is opposed to the approach based on data warehouses. To be selective means to filter the input information coming from external environment. A good filtering requires a deep understanding of the organization, specific knowledge on clients and a very good understanding of the strategic objectives.
- ✚ Knowledge centering leads to the information aggregation after self-organizing, collaboration and strategic alignment. Informational streams will activate the knowledge development and will facilitate the connections and necessary continuity to keep the unity and the coherence of the organizational intelligence.

- ✚ Open borders represents a very important aspect, if we want free movement for the ideas
- ✚ Multidimensionality brings organizational flexibility which ensures the fact the staff has the competencies, the perspectives and the cognitive abilities to solve problems

We conclude by saying that there are four ways for ICAS models to describe organizational knowledge management: creativity (generation of new ideas, perspectives, understandings, building products, services definition), problem solving, taking decisions processes, different implementations.

### 3. Conclusions

For a long period of time, those who tried to apply knowledge management practices have done it with a great inertia, based on empirical and intuitive principles. We consider that knowledge management „wave” is necessary in order to ensure a high degree of completeness and profoundness for knowledge management practices and to address all critique factors which will appear. Another practical benefit of knowledge management models is the fact that it helps to reach organizational purposes (through a better understanding of the elements which are involved)

These models helps us to understand what happens in the present (what we've gained so far) and offers a way to understand what is about to happen (forecasting) Synthesizing presented knowledge management models, we consider the following elements as being the main ones:

- ✚ Krogh and Roos model is following an epistemological approach and is emphasizing the idea of knowledge that is to be found both in the individual mind and in the relations between persons.
- ✚ Nonaka/Takeuchi models is centered on knowledge spirals, which can explain tacit knowledge transformation in explicit knowledge, this type of knowledge being considered ground base for learning and innovation, individual, group and organizational
- ✚ Choo/Weick model adopts an approach through which it tries to define the sense by analyzing the way how informational elements are found in organizational actions
- ✚ Wiig model is mostly based on the principle who states that knowledge can be useful only when it is organized using semantic networks, in order to ensure perspectives and purposes.
- ✚ Adaptive models are very well suited for modeling knowledge management processes, because the organization is treated as a living organism concerned with an independent existence and which is concerned with its surviving at almost any moment. Beer/Bennet applied this model in order to describe the cohesion and pressures which are manifested over ICAS systems.

### References

- ✚ Bennet, D: *“Organizational survival in the new world: the intelligent complex adaptive system”*, Butterworth-Heinemann, 2004
- ✚ Boisot, M.: *„Knowledge assets: securing competitive advantage in the information economy”*, Oxford University Press, 1999
- ✚ Choo C. : *“The knowing organization”*, New York, Oxford University Press, 1998
- ✚ Davenport, T, Laurence P.: *“Working knowledge: how organizations manage what they know”*, Harvard Business Press, 2000
- ✚ Dixit, A., Nalebuff, B.: *“Thinking strategically”*, W.W. Norton, New York, 1991
- ✚ James, D : *“Game Theory at Work: How to Use Game Theory to Outthink and Outmaneuver Your Competition”*, McGraw-Hill Professional, 2003
- ✚ Jay, L.: *“Strategic intelligence: business intelligence, competitive intelligence, and knowledge management”*, CRC Press, 2006
- ✚ Gleick, J: *“Chaos – making a new science”*, Penguin Books, Harmondsworth, Middlesex, 1987

- ✚ Nonaka, I, Takeuchi, H: *"The knowledge creating company: how Japanese companies create the dynamics of innovation"*, Oxford University Press, 1995
- ✚ Sven, J, Henrik L.: *"Intelligent management in the knowledge economy"*, Edward Elgar Publishing, 2003
- ✚ Von Krogh, Nonaka I.: *"Enabling knowledge creation: how to unlock the mystery of tacit knowledge and release the power of innovation"*, Oxford University Press, 2000
- ✚ Von Krogh, Roos, J: *"Organizational epistemology"*, St Martin Press, New York, 1995
- ✚ Von Krogh, Roos, J.: *"Knowing in firms :understanding, managing and measuring knowledge"*, Sage Publications, London, 1998
- ✚ Wiig, K.: *"Knowledge management foundations: thinking about thinking. How people and organizations create, represent and use knowledge"*, Schema Press, Arlington, 1993
- ✚ Wiig, K: *"People-focused knowledge management: how effective decision making leads to corporate success"*, Butterworth-Heinemann, 2004