

The role of enterprise architecture in knowledge conversion.

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In this article we explore the role of enterprise architecture in knowledge conversion. Enterprise architecture is high level, abstract representation of an enterprise and knowledge conversion is the creation of new knowledge from existing knowledge. Based on a literature research we can conclude that enterprise architecture provides a context for constructive dialogue, makes the concepts that are a result of knowledge conversion explicit and provides explicit knowledge for conversion processes. The role of enterprise architecture is limited due to the nature of the type of knowledge that is captured in enterprise architecture.

"It was a wise and useful provision of the ancients to transmit their thoughts to posterity by recording them in treatises, so that they should not be lost, but, being developed in succeeding generations through publication in books, should gradually attain in later times, to the highest refinement of learning." (Morgan, 1960). These are the words from Vitruvius, a roman architect who lived 85 – 20 years before Christ. Vitruvius is famous for his work "De Architectura", which is a classic in the field of architecture. Vitruvius wrote in his work about the fundamentals of architecture using the human body as a metaphor for buildings. In his seventh book he writes on the importance on knowledge, the above citation is derived from this seventh book. Vitruvius points out the importance of sharing knowledge so learning can be enabled. Like a bibliography today he gives his credentials to other authors in this book that enabled him to write De Architectura.

This illustrates that the concept of knowledge as well as the concept of architecture goes back many centuries. It is, so it seems, as old as it is new. In today's world knowledge has become the heart of many organizations and society as a whole. This requires a different approach to the role of knowledge in general and to how organizations deal with knowledge. The increasing importance of knowledge raises questions about how knowledge can be applied and created. The creation of knowledge is achieved by the conversion of tacit and explicit knowledge and their dynamic interaction. Nonaka is the main author in the field of knowledge conversion and bases his knowledge conversion theory on the distinction between tacit and explicit knowledge. This distinction was made by Polanyi in 1962 (Nonaka, 1994). Tacit knowledge is restricted to the domain of the individual members of an organization but explicit knowledge must be found outside a human and is captured in a codified form. The management of knowledge is partially directed by the structure of an organization. The way in which organizational activities and control are organized determine the information requirements in an organization.

Architecture is applied to the structure of these very same organizations. This form of architecture is referred to as enterprise architecture. Enterprise architecture is a high level,

abstract representation of the structure of an organization. It is build from an enterprise architecture framework that, based on dimensions, provides the views from which we look at the organization which is represented in models using a modeling technique. Enterprise architecture is based on the sub-architectural domains: business, information and technical architecture. Each of these domains describe the structure and the behavior of a specific aspect of the organization. These domains can be studied independently however they cannot be fully understood without looking at their interrelationship with the other domains.

The aim of this article is to develop an understanding of what the role of enterprise architecture is for the knowledge conversion modes as defined by Nonaka (1994). In the theoretical framework the concepts of knowledge conversion and enterprise architecture are further explored. The role of enterprise architecture for knowledge conversion is explored by mapping the theory of enterprise architecture to each of the knowledge conversion modes. The role of specific enterprise architecture methods in the knowledge conversion process is outside the scope of this article. This article will be concluded with a conclusion and discussion section.

Knowledge conversion

Knowledge can be best explained by its relation with the concepts of data and information. These concepts are closely related and often used interchangeably. This is not correct as there's a clear distinction that can be made. Data is derived from observations and measurements and has the form of numbers, images, words or sounds. Data on its own is trivial. Information is organized data. A meaningful pattern arises from intellectual input. Knowledge adds another intellectual layer to data and information. Knowledge emerges from using, analyzing and applying data/information. This is also captured in the definition of knowledge by Davenport and Prusak (1998, p.5) who say "knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and new information".

Knowledge can be divided into two categories: tacit knowledge and explicit knowledge. This distinction was made by Polanyi in his work in 1962 (Spender, 1996). Tacit knowledge is knowledge that resides within a person and because it is difficult to capture in a codified form this knowledge is difficult to transmit. Because of the nature of this knowledge it is subject to personal values en belief systems. With regards to tacit knowledge it is important to note that knowledge can be transmitted without the means of a formal language. Nonaka (1994) cites Polanyi who illustrates tacit knowledge by saying "we know more than we can tell" (p.16). Explicit knowledge is knowledge that exists outside a person and is captured in a codified form. This makes the knowledge easy to transmit. This knowledge is recorded in documents, records, databases, archives et cetera.

Knowledge conversion

Nonaka (1994) has developed a theory of knowledge creation based on the continuous interaction of tacit and explicit knowledge. The knowledge creation process is like an upward spiral. It starts small with just an individual but it expands fast when other actors get involved and it will go up to an organizational level and sometimes even an inter-organizational level. This spiral is a reflection of the knowledge conversion that results from the continuous interaction between tacit and explicit knowledge.

The essence of knowledge conversion is that new knowledge is created from existing knowledge. There are four modes of knowledge conversion that can be derived from the interaction between tacit and explicit knowledge. See table 1.

	To	Tacit Knowledge	Explicit Knowledge
From			
Tacit Knowledge		Socialization	Externalization
Explicit Knowledge		Internalization	Combination

Table 1: Modes of the Knowledge Creation (Nonaka, 1994)

Socialization can be described as the creation of tacit knowledge through a shared experience. Important here is that tacit knowledge can be transferred without the use of formal language. Sharing an experience is important because otherwise it is not possible to align on each other's thinking process. It forms a common base of understanding for the participants. In the early days this was a common way for a master to train his student in the skills of their craftsmanship. Nowadays the concept of training on the job in organizations is an example of creating tacit knowledge from tacit knowledge.

Externalization can be described as the conceptualization of tacit knowledge through dialogue. The tacit knowledge held by an individual is now brought into a social context. A strong role in this mode is for the use of metaphor. Metaphors can be used to share tacit knowledge. It helps to reveal otherwise hidden tacit knowledge by explaining a concept through the use of another concept. The concept of metaphor is strongly based on intuitive learning through symbols and imagination. An effective and efficient way of converting tacit knowledge to explicit knowledge is in the form of a self-organized team. Mutual trust is an important aspect because the conversion of knowledge is a result of dialogue amongst the team members. Through dialogue the ideas of the members are verified and build on and perspectives are shared. Information redundancy is a useful concept here as it allows team members to see things through a different perspective. Concepts are created through induction, deduction and abduction. With the creation of new concepts room for creativity is required and then abduction is more applicable than the reasoning from induction and deduction. Externalization is a time consuming process that will take repeated constructive dialogues between team members.

Internalization can be described as putting explicit concepts to test by applying the concepts and checking the usability. In this process explicit knowledge is converted to tacit knowledge. Learning by doing is of great importance here as experimenting with the explicit concepts is a trigger of the internalization process. Internalization supports the collective crystallization of the created concepts. The concepts are tested on their applicability and usability on a collective level by functions and departments spread in the organization. Information redundancy supports this process by creating the scope for the knowledge conversion process.

Combination can be described as the creation of explicit knowledge from explicit knowledge. This is done through social exchange processes like meetings and telephone conversations et cetera. New knowledge is created from existing explicit knowledge by means of "reconfiguring of existing information through the sorting, adding, re-categorizing, and re-contextualizing of explicit knowledge" (1994). A computer system is an illustrative example.

Each of these knowledge conversion modes is able to create new knowledge from existing knowledge. For an organization to expand their knowledge it is necessary that all four modes of knowledge conversion and their interrelationship are managed. The interrelationship between the conversion modes is outside the scope of this article and therefore it will not be further explored.

Information redundancy

A degree of redundant information in an organization is required for constructive knowledge conversion. Information redundancy occurs in social exchange processes when the members of a group receive information from the perspective of another member. For an individual this means that he gains insight into another member's viewpoint which enhances his overall understanding. From a collective point of view sharing perspectives means that a common ground can be created for the creation of concepts. Another function of information redundancy is limiting the diffusing perspectives in an organization. By sharing redundant information more common perspectives will be created. It replaces the many functionally narrowed perspectives of the members. Thus the sharing of redundant information will act as a regulator of perspectives by creating common perspectives and thereby reducing the number of perspectives.

Enterprise Architecture

Enterprise architecture can be described as a high level, abstract representation of a system. It describes the structure and the behavior of a system. There are various definitions that can be found in the literature. A highly influential definition of architecture was developed in the IEEE 1471-2000 standard on 'Recommended Practice for Architectural Description of Software-Intensive Systems' (Goethals, 2006). The definition of architecture by IEEE 1471-2000 is "the fundamental organization of a system embodied in its components, their relationship to each other and the environment and the principles guiding its design and evolution" (Maier in Goethals, 2006, p.69). An enterprise can be conceived as a system and thus is this definition of architecture expandable to enterprise architecture as well.

Enterprise architecture has emerged from the notion that business and IT must be aligned. By the architecture of the enterprise a holistic approach to the various domains of an enterprise is taken. Enterprise architecture provides a high-level view of the components and their coherence. The most common distinctions between domains in enterprise architecture are (Aerts, 2004):

- *Business*: this is the domain that represents the business system in its environment. The system is made up by persons, resources, processes and rules.
- *Application*: this is the domain that represents the software applications and their relationships.
- *Technology*: this is the domain that represents the generic resource layer. This is made up by computers, networks, database systems, peripherals, middleware etcetera.

A holistic approach of domains implies that there's an inter-domain relationship. Changes in one domain have an affect on the other domains. In this inter-domain relationship a distinction can be made between a 'driver' relationship, an 'enabler' relationship and an 'alignment' relationship. (Aerts, 2004) A drives relation is characterized by the fact that a change in one domain dictates a change in the other domain. A enables relation is characterized by the fact that a change in one domain creates opportunities in the other domain. For example by implementing new software, opportunities for working more effectively may occur in the business domain. An alignment relation is established by mutual influence of both domains in balanced manner. The relationships are graphically represented by Aerts (2004). See figure 1.

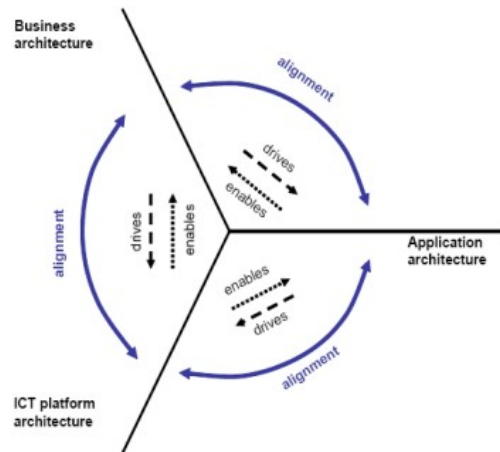


Figure 1: dimensions of alignment (Aerts, 2004)

Enterprise architecture is an instrument to gain understanding of the enterprise. Understanding means knowing what the elements are, how they relate to each other and how they work together. Furthermore it also creates awareness of the role of the enterprise in its environment. One of the main functions of enterprise architecture is to act as an instrument by offering a means of communication to parties that are concerned with the enterprise. Furthermore it can also act as a planning and steering instrument for actual developments and the realization of plans, as a means of evaluation and comparing of alternative systems. In order for enterprise architecture to meet the requirements of these functions it uses architectural frameworks, viewpoints and models.

An architectural framework is an instrument that provides an approach to how the enterprise is described by architectural descriptions. An architectural description is defined as “a collection of products to document an architecture” (Maier in Goethals, p. 69). There are many different architectural frameworks but in general a distinction can be made between frameworks for the enterprise as a whole and frameworks for application architecture. Which framework is appropriate mainly depends on the underlying reasons for the enterprise architecture undertaking. It is the one that provides the most adequate answers in the given context.

A framework typically consists of dimensions that are organized along axes. On each dimension there are usually multiple aspects. To generate a meaningful perspective on the enterprise, which is context-dependent, usually more than one dimension is required. Architectural frameworks are developed to structurally relate dimensions. Nine base dimensions in enterprise architecture frameworks can be distinct from which the first five are commonly used (Greefhorst, 2006):

- *Type of information.* This dimension is the most basic of all and it determines what is described in the architecture. At the highest level this dimension distinguishes between domains like business, application and technology.
- *Scope.* This dimension covers the scope of the information which determines to what extent the information needs to be covered. The aspects of this dimension are ideally organized in a top-down manner because that way it can be easily understood. An example is: industry, sector, organization, domain, system family, system, and component.
- *Detail level.* This dimension is concerned with the level of detail of the information presented. The reason for varying in the detail level is to represent the relevant information only for a particular context. For example the levels high, medium and low can be distinguished.
- *Stakeholder.* This dimension uses the stakeholders that are addressed by the enterprise

architecture as a main criterion. Stakeholders are typically interested in a specific aspect of the enterprise architecture. For example the stakeholders client, end-user, architect, analyst and developer can be distinguished.

- *Transformation.* This dimension uses changes over time as a criterion reflecting the transformation phases that the architecture has to go through. It can distinguish between the current situation, short-term, mid-term and long-term.
- *Quality attribute.* This dimension reflects quality attributes. It shows the attribute that is being addressed. For example: functionality, reliability, usability, efficiency, maintainability, portability.
- *Meta level.* This dimension reveals the amount of abstraction. It is information on information. It is similar to the detail level dimension however the type of information is different. An example is: instance, model, meta-model, meta-meta-model.
- *Nature.* This dimension reflects the nature of the architectural information. For example: policy, principle, guideline, description or standard.
- *Representation.* This dimension distinguishes between the way in which the architectural information is represented. It reflects the nature of the language that is used to present the architectural information, for example: formal, semi-formal or informal.

The most well-known framework is the Zachman framework that was developed in the eighties by IBM (van den Heuvel, 2002). It is a classical, generic framework consisting of 2 dimensions each containing 6 aspects. The framework cells combine the notion of the one dimension with the notion of the other dimension. This is also referred to as viewpoints. The Zachman framework contains 36 viewpoints. Viewpoints are an important concept in enterprise architecture (Proper, 2008). It is commonly recognized that the enterprise has various stakeholders and that their interest in the enterprise differs. By the IEEE 1471-2000 standard it is proposed to organize the architectural descriptions around views that represent a set of stakeholder concerns. The viewpoint specifies what is considered to be relevant in order to describe a certain aspect of the system. Models are the instrument used for the architectural descriptions of a viewpoint. The main function of a model is to act as a means of communication. This is illustrated well by the saying "a picture says more than a thousand words". Models are multifunctional and can be used to present the function, construction or foundation of a system, they can represent aspects of a system like what, why, what with and how (definition and design), they can highlight a certain type of information about a system using a specific perspective and they can represent other aspects of the systems like the actors, their roles, the goals et cetera. Models are created through modeling for which there are several techniques developed. A modeling technique is a way of modeling which determines the way of delivering made up by a way of describing and way of conceiving. The way of modeling "identifies the core concepts of the language may be used to denote, analyze, visualize and/or animate the systems descriptions" (Proper, 2008, p. 39). The way of conceiving refers to the notation of the concept, e.g. graphics or text and the way of describing refers to the actual notations of the concepts. Before the actual modeling starts, a number of things should be taken into consideration such as what parts of the domain are relevant and the level of detail that is required, the target audience. Other important considerations are if the model will have to reflect the current situation or the desired situation and whether it represents what a system does or how it does it. In addition to modeling a single viewpoint it is essential to establish the relationship between the models, e.g. the relation of a certain process step in a process model with an application component in the component model. The dependencies and relationships within and between the domains become clear by these composite models, see figure 2 for a graphic illustration.

Relations between models

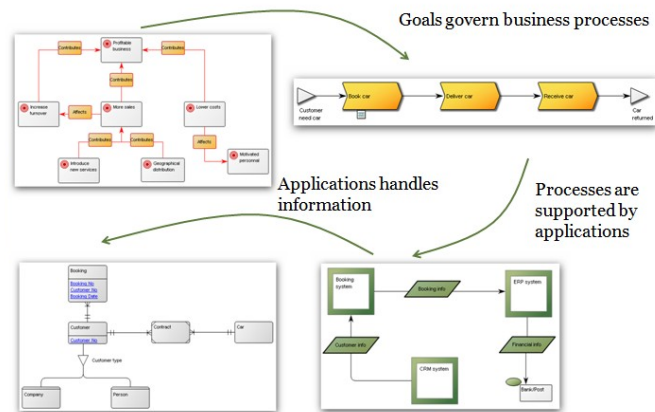


Figure 2: Relation between models (Qualiware, 2008)

Enterprise architecture software

Enterprise architecture software is an essential tool to enhance the understanding of the enterprise through enterprise architecture. In an enterprise architecture software tool the models can be created and stored and the relationships between the elements are visualized. Once an element is created it can be re-applied to various other models. A software tool makes it possible to generate a dynamic view on the enterprise through linking the models. It shows a model hierarchy within a view, but can also generate a combined view using information from other views. Another common feature of software tools for enterprise architecture is the function to convert the models into HTML format. This generates a more user-friendly environment and in this format the models can be disclosed to a broad audience through portals or intranet sites.

Results

Now the theoretical foundation has been laid, the role of enterprise architecture in knowledge conversion can be explored. This will be done by mapping the theory of enterprise architecture to each of the knowledge conversion modes. For each of the knowledge conversion mode the outcome is established. From there it will be explored what enterprise architecture can contribute to that outcome in the broadest sense of the word. This means that any contribution enterprise architecture can offer to one of the knowledge conversion modes is considered relevant.

Socialization. The result of this knowledge conversion mode is new tacit knowledge deduced from a shared experience. An important element of this process is sharing an experience so individuals can align on each others thinking process. Thus, the main question is what the role of enterprise architecture can be in a shared experience so that it will generate new tacit knowledge for an individual. The answer must be that there's no role for enterprise architecture in this process because tacit knowledge that is derived from enterprise architecture is per definition created from explicit knowledge.

Externalization. The result of this knowledge conversion mode is explicit knowledge deduced from tacit knowledge. One key element of this process is constructive dialogue in which perspectives are shared so the knowledge that resides within individuals can become explicit. Thus, the main question is how enterprise architecture can help making the knowledge explicit. For the externalization process to be successful the dialogues between members need to be constructive. Enterprise architecture can offer support so that dialogues can become

constructive dialogues. The enterprise architecture framework of choice provides the context within which the dialogue should take place. The viewpoints of the framework are the topics for a dialogue. Enterprise architecture can be used in a prescriptive or descriptive manner. Thus, the dialogues can be held to reach consensus about what the current state (also referred to as AS-IS) is or they can be held to determine a desired situation (also referred to as TO-BE). Once a consensus is reached the modeling technique will then support a commonly recognized representation of the developed concepts. From a more practical point of view the enterprise architecture software tool will offer a repository that stores the concepts that have been converted into explicit knowledge. The role of enterprise architecture in the externalization process is that creates explicit knowledge from tacit knowledge can thus be described as guiding the process by providing a specific context and a method to make the concepts explicit.

Internalization. The result of this knowledge conversion mode is tacit knowledge derived from applying explicit concepts. Key to this process is learning by doing. The question of interest in this case is how enterprise architecture can play a role in this action oriented process. For this process enterprise architecture is the supplier of the concepts that need to be tested and checked with reality. The models and their inter- and intra-relationships are subjected to this process. In this process enterprise architecture also facilitates by offering redundant information. The models of enterprise architecture provide an overview that is, in many cases, broader than the work domain of a member. The overview enables the member to place the concepts in a wider context than he can perceive from his work domain. The role of enterprise architecture in the externalization process that creates tacit knowledge from explicit knowledge is that it is the supplier of explicit knowledge.

Combination. The result of this knowledge conversion mode is explicit knowledge generated from explicit knowledge. It encompasses the reconfiguring and re-categorizing of existing information through social exchange processes. Thus, the main question is what enterprise architecture can contribute to the reconfiguring and re-categorizing process. In this process enterprise architecture is the repository of the initial concepts that are subject to re-categorizing and reconfiguring. What knowledge is called for depends on the viewpoint and the level of abstraction chosen. The enterprise architecture models vary in the level of detail. Detailed models offer specific knowledge about a particular aspect of the organization. More abstract models offer an overview which is valuable for creating insight and reducing complexity. Enterprise architecture supports the principle of information redundancy by offering knowledge in various domains, from various viewpoints using various levels of abstraction. For each aspect that is modeled the inter- and intra-domain relations can be called upon. The role of enterprise architecture in the combination process that creates explicit knowledge from explicit knowledge is that it is the supplier of initial concepts.

Conclusion & Discussion

In this article the role of enterprise architecture in knowledge conversion is explored through mapping the concept of enterprise architecture with the concept of knowledge conversion. The results of this show that the role of enterprise architecture in knowledge conversion can be summarized as follows:

- Enterprise architecture provides a context for constructive dialogue.
- Enterprise architecture makes the concepts that are a result of knowledge conversion explicit.
- Enterprise architecture provides explicit knowledge for conversion processes.

More specifically it can be concluded that: the enterprise architecture framework provides the

context for dialogue through the architectural viewpoints that provide the topics to be discussed. The architectural model will show the concepts in a manner in which they're commonly recognized through the modeling technique. The concepts that are created and modeled function as input for the phases of internalization and combination. In the internalization mode they're tested on their practical and accurate representation of reality. The models show information that is relevant for a particular view. Often this goes beyond the specific work domain of a specific member and thus the member is confronted with so called redundant information. The combination mode uses the information from enterprise architecture to generate new explicit knowledge by re-configuring and re-categorizing the information. As the results show enterprise architecture has a role in all the knowledge conversion modes except for the socialization mode. The socialization mode creates tacit knowledge from tacit knowledge and enterprise architecture involves explicit knowledge by definition.

In this article the role of enterprise architecture in general has been explored. As a result the role of enterprise architecture that has been established for knowledge conversion is limited. The knowledge that is subject to the various modes of knowledge conversion is restricted to knowledge about the structural elements of an organization and their interrelationships. The knowledge in an organization that should be managed and is subject to knowledge conversion is much broader than the knowledge covered by enterprise architecture. But then, the architectural frameworks, that determine what knowledge is covered by their viewpoints, aren't designed for the discovery of all knowledge assets in an organization. From this it must be concluded that enterprise architecture can play a role in knowledge conversion but only partial. There are architectural frameworks that contain knowledge viewpoints, such as Evernden Eight. It would be interesting to find out if their role in knowledge conversion is different from the other architectural frameworks and how it is different. Further research in the field of knowledge conversion and architectural frameworks is required to establish whether the role of architectural frameworks that include knowledge viewpoints differs from the role of enterprise architecture in general.

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References

- [Aerts, 2004] Aerts, A.T.M, Goossenaerts, J.B.M., Hammer, D.K., Wortmann, J.C. "Architectures in context: on the evolution of business, application software, and ICT platform architectures." *Information & Management* , 2004.
- [Arbab, 2006] Arbab, F., de Boer, F., Bonsangue, M., Lankhorst, M.M., Proper, H.A., van der Torre, L. "Integrating architectural models: symbolic, semantic and subjective models in enterprise architecture." *Elsevier Science*, 2006.
- [Davenport, 1998] Davenport, T.H., Prusak, L. *Working Knowledge: How organizations manage what they know*. Cambridge: Harvard Business School Press, 1998.
- [Goethals, 2006] Goethals, F., Snoeck, M., Lemahieu, W., Vandenbulcke, J. "Management

and enterprise architecture click: The FAD(E)E framework." *Information Systems Frontiers*, 2006.

- [Greefhorst, 2006] Greefhorst, D., Koning, H., van Vliet, H. "The many faces of architectural descriptions." *Information Systems Frontiers*, 2006.
- [Hislop, 2005] Hislop, D. *Knowledge management in organizations. A critical introduction*. Oxford: Oxford university press, 2005.
- [Jonkers, 2006] Jonkers, H., Lankhorst, M., ter Doest, H., Arbab, F., Bosma, H., Wieringa, R. "Enterprise Architecture: Management tool and blueprint for the organisation." *Information Systems Frontiers*, 2006.
- [Kirikova, 2000] Kirikova, M. "Explanatory capability of enterprise models." *Data & Knowledge Engineering*, 2000.
- [Morgan, 1960] Morgan, M. *The ten books on architecture/Vitruvius [translation from latin]*. New York: Dover, 1960.
- [Nonaka, 1994] Nonaka, I. "A dynamic theory of organizational knowledge creation." *Organization Science*, 1994.
- [Proper, 2008] Proper, E. "Erik Propers - Courses." *Erik Proper*. January 24, 2008. <http://erikproper-courses.blogspot.com/> (accessed March 28, 2009).
- [Sitter, 2000] Sitter, Prof. dr. L.U. de. *Synergetisch produceren. Human Resources Mobilisation in de produktie: een inleiding in structuurbouw*. Assen: Van Gorcum, 2000.
- [Spender, 1996] Spender, J.C. "Organizational knowledge, learning and memory: three concepts in search of a theory." *Journal of Organizational Change Management*, 1996.
- [van den Heuvel, 2002] van den Heuvel, W., Proper, H. "De pragmatiek van architectuur." *Informatie*, 2002.
- [Visser, 2009] Visser, M. "Diagnosis Organizational Learning Capability (DOLC); the making of an instrument." *9th EURAM Annual Conference. 11-14mei*. Liverpool, 2009.