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EMBEDDING KNOWLEDGE: ISSUES IN THE DEVELOPMENT OF NEW INFORMATION TECHNOLOGIES.

Theme: The Social Processes of OL and KM

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Abstract

This paper investigates issues relating to the creation, maintenance and use of compled informaion systems such as Enterprise Resource Planning (ERP) systems. These systems may be considered to 'embed' rich knowledge concerning organizations and their environments. We investigate the notion of information systems embedding knowledge and conclude that the context within which the information system is created, maintained an used enables such embedding. Two different perspectives are used to investigate difficulties that may arise when the knowledge embedded in different systems is combined within organizations as a basis for action. The first approach models the 'mismatches' between the contents of different information systems, or memory media, within and organization. The second approach uses an analytic approach based on classification theory.
In addition to developing two perspectives on problems associated with embedded knowledge possible strategies for alleviating such problems are discussed and directions for future research suggested.

Introduction

In seems very obvious to say that information systems embed knowledge. However, in the following paper we consider a number of ways of unpacking this concept and giving it somewhat more depth. In this paper, we are particularly concerned with approaches that allow for the identification of situations where knowledge is incompletely embedded in information systems that are critical to organizations. Our analytic approaches to investigating the embedding of knowledge in information systems and the failure to embed critical knowledge in such systems have been developed in two different but ultimately related streams of work. One stream started with developing models to investigate how complex information systems such as ERP systems might be unsuccessful in use. The approach adopted was to consider the memory contents of different organizational memory stores. An analytic framework was developed to model potential 'mismatches' between these diverse memory stores.

The other approach also developed with initial reference to ERP systems, considered a somewhat more foundational approach to analyzing the way in which information is embedded in information systems. We considered that a fundamental pre-condition of developing any information systems whatsoever is the development of a classification system. We were concerned with two distinct aspects in the development and subsequent use of such classification systems. In the first place classification systems exist within a context. Among other things this context provides a framework that facilitates the classification of new experiences. Classification schemes do not typically bring with them the context that is relevant to their interpretation and use. To the extent that knowledge embedded in information systems is continually being updated understanding classification schemes 'in use' is fundamentally important. A second concern we had, which can be related to our 'mismatch' approach, is that when attempts are made to combine knowledge from different information systems there is potential for mismatches between classification schemes. In a similar vein to our research on memory mismatches we developed an initial analysis of the types of classification mismatch that might occur.

We consider that the approaches that we have adopted provide potentially interesting insights into the ways in which knowledge is embedded (or fails to be embedded) in organizational information systems. We expect to be able to use the tools that we have developed to investigate further the ways in which information systems are initially developed and also behave 'in use'. The latter study is likely to throw light onto issues that have been subjected to only limited study in the past.

The organizational memory mismatch approach

Organizational memory theory

Organizational memory may be defined as "[...] stored information from an organization's history that can be brought to bear on present decisions" (Walsh and Ungson, 1991:61). In addition to information, other types of memory contents are recognized, for instance knowledge (Stein, 1995) and paradigms (Wijnhoven, 1999). Memory contents may be stored in different locations or repositories that make up what we call a memory base (Walsh and Ungson, 1991; Wijnhoven, 1999). Organizational memory processes, such as search and retrieval (Stein, 1995), operate upon the memory contents, thus enabling their actual use in supporting action within organizations. These three aspects of organizational memory, contents, repositories and processes, are further discussed below.

Organizational memory contents

Organizational memory contents are the cognitive elements that form the memory base. Different authors label and classify memory contents differently (Moorman and Miner, 1997; Robey, Wishart, and Rodriguez-Diaz, 1995; Stein, 1995; Walsh and Ungson, 1991). One may, however, distinguish four separate, more general types of memory contents, which may be referred to as information, knowledge, paradigms and skills. Information is "[…] the flow of messages, while knowledge is created and organized by the very flow of information, anchored on the commitment and belief of its holder" (Nonaka, 1994, p.15). Thus, information may become knowledge when the receiver interprets the messages.

Knowledge, or a knowledge structure, is "[…] a mental template that individuals impose on an information environment to give it form and meaning" (Walsh, 1995, p. 281). Knowledge structures thus represent what are called 'interpretive schemes' in structuration theory. Such interpretive schemes are comprised of shared stocks of knowledge which help human actors to give the world meaning (Orlikowski and Robey, 1991).

If we unpack the distinctions that we are drawing between knowledge and information further. The information in various memory stores is interpreted through individuals and groups of individuals. Information requires a context I which to be interpreted. Memory stores do not contain within them the context that is necessary to interpret them. Thus, the information in a particular memory store may be interpreted in different ways depending on the context in which such interpretation takes place. It is also appropriate to question whether knowledge structures or interpretative schemes built up through interaction with a particular domain, environment and set of tasks are appropriate in situations where major changes occur

in any of these elements. These questions will be further examined in the second part of this paper where we provide some discussion of the ways in which information is classified.

The third content type, paradigms, consists of the organizational beliefs, governing values and norms (Wijnhoven, 1999). In a similar manner to structuration theory's 'norms', paradigms represent the beliefs and rules about 'what is good and what is bad', about what one should and should not do. These again require a rich contextual background that is not explicitly represented in any of the information encoded in any of the memory stores in an organization. Though, it may be possible to reconstruct some of this context through analysis of what is included or excluded from memory stores.

The fourth content type, skills, is comparable to what some refer to as tacit (Nonaka, 1994) or soft knowledge (Anand, Manz, and Glick, 1998). Skills refer to the capabilities of people, 'how they do things'. These capabilities thus have a personal quality, deeply rooted in action, commitment, and involvement in a specific context (Nonaka, 1994). Only if individual members of the organization are willing to and capable of sharing tacit knowledge or helping in the development of skills by others, is the organization able to have access to these skills. Again it would seem appropriate to ask whether such norms might be embedded in different memory stores and, thus during use create problems with respect to mismatches. In addition, norms may fail to evolve appropriately and result in 'mismatches' between organizationally embedded information and other sources of information.

The four identified content types may be independent of a specific application area or domain, but they may also be domain-dependent, depending on a specific business process, organizational unit, the organization in general, or the industry or the nation(s) in which the organization operates. Memory contents may be stored in one or more different retention media; these are discussed in the next subsection.

Organizational memory media

Though some argue that such storage of memory contents may be interpreted metaphorically rather than literally, one can at least assume that the various repositories imply memory contents, such as knowledge and information. For instance business processes, or transformations, are based upon knowledge regarding what input is needed and what actions should be undertaken in order to produce a certain output. "[…] The logic that guides the transformation of an input into an output is embodied in these transformation" (Walsh and Ungson, 1991:65). This logic may be called 'technological knowledge'. That is the knowledge about how to produce goods and services and understanding the effects of the input variables on the output (Bohn, 1994). The transformations occur throughout the organization and similarly, memory is preserved in a variety of procedures and formalized systems (Walsh and Ungson, 1991). As an increasing proportion of the process knowledge of organizations is embedded in such systems as ERP systems the potential for conflict to occur between the knowledge embedded in these systems and other process knowledge embedding structures and memory sources rises.

Next to transformations, Walsh and Ungson (Walsh and Ungson, 1991) describe the following storage media for organizational memory: individuals, culture, structure, ecology, external archives. The term ecology refers to the actual physical structure or the workplace ecology of an organization (Walsh and Ungson, 1991). An organization's physical setting

often reflects the status hierarchy in the organization and helps to shape and reinforce behavior prescriptions in the organization. In a broader sense, other physical artifacts existing in the organization may be considered, including for instance the available machines, the products and product lines. Such physical artifacts "[…] embody, to varying degrees, the results of prior learning" (Moorman and Miner, 1997:93). Additionally, information systems have been recognized as another important repository (Stein and Zwass, 1995; Wijnhoven, 1999). "[…] Information technology can also capture many routines stored in memory by embedding those routines within its programs and procedures. Through electronic storage, memory may become more accessible to organizational members" (Robey, Wishart, and Rodriguez-Diaz, 1995:28). Interestingly, this increased accessibility may have both positive and negative consequences. From a positive perspective it may result in the more consistent application of routines. However, from a negative perspective it may result in the misapplication of routines and the failure to adapt routines to changing situations.

Organizational memory processes

The defining processes of organizational memory are acquisition, retention, maintenance, and retrieval (Stein, 1995). Memory acquisition is the collection of new memory contents and memory maintenance is "[...] the process of adjusting existing memory to changed environments (application areas) in such a way that the basic part of the memory is still applicable despite these changes" (Wijnhoven, 1999:172-173)." Memory maintenance, in other words, is about adapting and updating the memory. Other concerns of memory maintenance are the forgetting of obsolete memory contents, and the integration of new memories with existing memory contents (Wijnhoven, 1999). Memory acquisition and memory maintenance together form the processes of organizational learning; organizational learning may be considered to be specifically concerned with the growth and change of organizational memory (Duncan and Weiss, 1979).

Memory retention refers to the actual storage of the memory contents in the memory media. Some memory media are more robust than other memory media. The contents of some memory media may be relatively stable while other contents may degrade over time. One interesting notion is that one way in which memory contents may effectively degrade is that the context appropriate for their interpretation may dissipate. The various components that retain this context, most specifically particular individuals, groups or other structured relationships may gradually (or sometimes rapidly) dissipate. As a result it may become increasingly difficult to interpret the contents of various organizational memory stores. Thus, embedded knowledge may be lost. In addition to memory retention the other processes of memory search and retrieval deal with finding and obtaining memory contents after storage.

Organizational memory mismatches

An Enterprise Resource Planning (ERP) system may be viewed as part of an organization's memory base, being a retention medium (information system) that embeds memory contents. All four types of memory contents may be embedded in the ERP system. For example information regarding financial resources or technological knowledge regarding logistic planning are embedded in the ERP system, e.g. logistic planning modules. Paradigms also underpin an ERP system. For instance, paradigms relating to best practices (cf. Kumar and Van Hillegersberg, 2000) and effectiveness are included explicitly in e.g. inventory schedule

modules. Skills can also be included as well, either elicited in the form of routines or decision models, or in the form of a skill database in the human resource component of the ERP system, linking employees and skills.

It is our contention that organizational memory mismatches may exist between the memory contents of the ERP system and related memory contents of other memory media (Van Stijn and Wijnhoven, 2000). For instance, the sales planning component of the ERP system (the representation of the sales planning process) may be used to predict future sales based upon previous sales. However, the underlying assumption in the ERP system is that those sales in the past are representative for the future and that no specific 'events' have occurred that may alter the pattern. However, the sales manager may know that another company has started selling a similar product at a much lower price, which may be regarded as one of those events that disrupt the previous pattern. As a result a memory mismatch exists between the memory content of the ERP system and the memory content of the sales manager. Forecasts made with the ERP system may be systematically too high, which would have a negative consequence for the whole logistic and financial planning. Such a memory mismatch is very likely to lead to ERP under-performance, which means that the intended benefits of the system, and hence the organization as a whole, are not achieved.

Cognitive dissonance theory, as developed by the psychologist Festinger (1957) offers a starting point for the further definition of organizational memory mismatches (cf. Van Stijn and Wijnhoven, 2000). For our discussion of memory mismatches, two extensions are made to Festinger's approach to cognitive dissonance. First, instead of comparing memory contents within one medium (the individual's mind), the memory contents of the ERP system are compared with those of other retention media. Related contents of the different media may therefore be dissonant or consonant to each other. The second addition we make to Festinger's analysis is that we extend the concept of dissonance to include situations where memory contents are missing where they should be present and situations where memory contents are present in both media where only one instance of the memory content should be present (Van Stijn and Wijnhoven, 2000). We refer to the former situation as one of under-redundancy and the latter as over-redundancy. Thus, we distinguish three types of organizational memory mismatches, namely under-redundancy, inconsistency, and over-redundancy:

Type I. Under-redundancy
The memory content item, A, is missing from one memory retention medium and another memory content item, B, is missing from another memory retention medium when both items should be present.

Type II. Over-redundancy
A memory content item, C, is present in two or more memory retention media.

Type III. Inconsistency
One memory retention medium contains a memory content item, D, while another memory retention medium contains the negation of this memory content item, ~D.

The above types of memory mismatches form the core of the organizational memory mismatch approach, where they are related to potential under-performance of the ERP system and also to coping behaviors, i.e. further enhancement of the ERP system in broad sense.

Discussion of the organizational memory mismatch approach

As we have discussed in this paper, the different types of knowledge embedded in different types of memory retention media may not be the same as the knowledge that is embedded in the organization's ERP system. When knowledge does not match, one can speak of organizational memory mismatches (Van Stijn, 1999). If these mismatches are not reconciled, it is our contention that the organization will exhibit characteristic behaviors and is likely to under-perform in the usage stage of the ERP system (Van Stijn and Wijnhoven, 2000).

A number of additional issues immediately arise. What do individuals and groups within the organization do when faced with such mismatches? There are a number of strategies – one memory source may be considered to dominate other stores. In other cases further investigation might be instigated to explore possible reasons for the mismatch. If a knowledge source other than the ERP system is trusted it may become necessary to make use of 'work arounds' so that the ERP system functions appropriately even though, given the knowledge embedded, it would not perform in this way. Of course, one of the problems of adopting this approach is that senior management does not receive any signals that there are problems with the knowledge that is embedded in the ERP system. It is also appropriate to note that it is unlikely that adaptation will take place in these situations as 'work arounds' are rarely acknowledge by those who make use of them particularly if they are seen as a way of subverting the information system. An interesting area for future research concerns both the identification of these work arounds and also a study of how knowledge that is embedded in such work arounds can be recognized.

An Alternative Viewpoint – Different Approaches to Classification

In a related stream of research Duimering and Wensley (2001) have investigated the intersection of classification theory and information systems. This allows us to look at potential organizational memory mismatch issues from a different perspective and at a different level of granularity. The starting point for this alternative perspective is the observation that different organizational memory media may make use of different approaches to classification. That is, the memory contents of different media may differ as a result of using a particular classification scheme in a different way or indeed using a different classification scheme altogether. We refer to the problems arising from such classificatory divergence as problems of knowledge combination.

Central to our concern with classification schemes is our concern with the context within which such classification schemes are created and used. It is our contention that knowledge can only be said to be embedded in such systems if we take into account the interaction between the context within which such systems are created or used and the information that is embedded in them. In the following section we focus, however, on difficulties that arise as a result of trying to combine information from classification systems that are incommensurate. We define three general classes of information combination difficulties associated with

interactions between incommensurate categorization schemes: 1) Basic level inconsistency, 2) Category-object inconsistency, and 3) Category-category inconsistency.

Basic level inconsistency

When the classification scheme used for one memory store is more complex and detailed than that of the other memory store combining knowledge from one store may require the combination of contents encoded in somewhat vague and imprecise categories with information encoded in much more precise and detailed categories.

In her dissertation examining the process of communication as a function of set structure, Purdy (1989:1) provides the example of Joe Handy, which captures the essence of these sorts of difficulties. Joe is a novice handyman attempting to purchase some screws from a hardware store for a home carpentry project. Although his request for screws seems perfectly reasonable to him, since he knows that he does not require other types of fasteners (nails, nuts and bolts, etc.), its vagueness is met with confusion by the clerk at the hardware store, who knows that there are many different kinds of screws (for use with wood or metal, a variety of different lengths and diameters, etc.). We may view this as a problem associated with the 'granularity' of classification schemes. Although it is, in principle, possible to combine information from two different sources information is lost – the only way combination can take place is by ignoring the detail presented in one of the information sources.

Category-object inconsistency

A different type of problem is likely to arise when, although the information in two memory stores may appear to be classified in the same manner, the meaning of the classification schemes is different. To the extent that different memory stores were created with respect to differing contextual frameworks their contents may actually be incommensurate even though they appear to use the same terms. For example, when categorization schemes are instantiated it is often with reference to prototypical examples of each category. New contents are assessed with respect to their similarity with respect to established prototypes and placed in categories accordingly. It is perfectly conceivable that two memory sources make use of the same categorization schemes but classify the same objects in different categories. The degree to which category prototype models differ between the two memory sources, would influence the degree of difficulty encountered in combining information from each of them. Such inconsistencies may be difficult to trace and also difficult to correct.

An interesting area of further enquiry relates to the identification and sharing of prototypical members of particular categories. It would appear that these prototypes are often established through informal storytelling in organizations. Colleagues may share stories of excellent service, satisfied customers, difficult customers and so on.

Category-category inconsistency

Finally, information combination difficulties arise when the information in two different memory sources is simply classified along fundamentally different dimensions. For instance,

Bowker and Star (1999:22-23) present a table indicating causes of death for England during the latter half of the seventeenth century. Typical causes of death at the time included "itch", "jaw-fln" and "suddenly"—categories that no longer have any real meaning in current medical discourse. Medical researchers attempting to use this seventeenth century data to reconstruct the causes of death in current terms would have a difficult time. The two patient death categorization systems are mutually inconsistent and no straightforward transformation function exists for combining information retrieved from one source with information from a contemporary source.

Organizational examples of such information combination difficulties are common. For instance, an accounting information system might organize business expenditures into classes of allowable expenses and depreciable capital investments, conforming to the constraints of public accounting standards, many of which are mandated by legal taxation authorities. On the other hand, a department manager may consider such distinctions to be irrelevant for decision-making purposes, and be more concerned about tracking cash-flow on a weekly basis in order to decide when to place purchase orders for certain items. The two classification schemes are largely inconsistent and complex transformations may be required to reconcile the two ways of framing the organization's financial transactions.

A researcher investigating a problem that crosses traditional academic discipline boundaries is likely to encounter similar difficulties when searching library databases for prior research findings. Although the researcher's problematic search is framed by the particular requirements of the research problem, library resources are likely to be organized using a standardized discipline-based classification scheme, such as the Library of Congress system, that may use a variety of different keywords to represent similar phenomena occurring in different disciplinary domains.

Some further reflections on context, classification and the embedding of knowledge

In the above we have identified a variety of different classification problems that may arise as a result of insufficient attention being paid to the context within which different classification systems have been developed. As we have noted earlier context is a vital aspect that allows for the interpretation and application of information, for the unpacking and use of embedded knowledge. Without an adequate understanding of context we are unable to interpret information which is present in information systems. Thus, although there is a sense in which knowledge may be embedded in information systems more strictly knowledge is embedded in the complex interaction between information systems and the context within which they are created, modified and used.

We have been concerned in this paper with what we have termed 'mismatches' between the knowledge that is embedded in different information systems or memory stores. We have examined the nature of these mismatches as they might occur at one point in time. Such mismatches cause potential problems for individuals, groups and organizations when actions are taken based on knowledge that is embedded in these different systems. Considering a static analysis it becomes necessary to develop a coping strategy with respect to such mismatches. Such coping strategies have both immediate effects and are also likely to

establish long term patterns of behaviour. Even if such long term patterns of behaviour result in appropriate behaviour they are likely to be problematic. As we have noted, at the very least senior management will be unaware of the existence of such conflicts and the 'workarounds' that have been used to avoid them. Because of this it is likely that no efforts will be made to investigate the mismatches themselves and as a result no corrective action will be taken. There is clearly a need to investigate these behaviours in more detail.

However, there is also a dynamic dimension to the issue of mismatches. As individuals, groups and organizations evolve, embedded knowledge interpreted through the lens of changing contexts may become distorted or even fundamentally uninterpretable as in the case of the medical knowledge embedded in the death statistics referred to earlier. Although it seems quite acceptable that the medical knowledge embedded in pre-scientific death statistics should be lost organizations should clearly be concerned when this occurs over much shorter time spans.

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