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Knowledge Management Based View of Information System Development Process

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ABSTRACT

By viewing information system development (ISD) process as a knowledge work different factors related to the creation and sharing knowledge can be identified as possible causes of ISD methodologies low acceptance and mode of use. Knowledge-related problems in ISD process are divided into three main categories, namely: the tacitness of application domain knowledge, the tacitness of ISD methodology knowledge and the symmetry of ignorance in ISD process. This paper uses Tuomi's knowledge creation model to identify knowledge-manipulation activities required in each phase of ISD process.

INTRODUCTION

Although the capability of methodologies to improve the productivity and quality of information systems developemnt (ISD) process has commonly been acknowledged, systematic use of methodologies is still surprisingly low (Smolander et al., 1990, Aaen et al., 1992). Thus, there is a paradox here between the claimed advantages of methodologies, which should indicate high use, and the empirical observations revealing low acceptance of them. Moreover, Fitzgerald (1997) found there is a wide difference between the formalized sequence of steps and stages prescribed by a methodology, and the methodology-in-action uniquely enacted for each development project. The author also found that developers omit certain aspects of methodologies, not from a position of ignorance, but from the more pragmatic basis that certain aspects are not relevant to the development environment they face.

By viewing ISD process as a knowledge work (Iivari, 2000) different factors related to the creation and sharing knowledge can be identified as possible causes of ISD methodology low acceptance and mode of use. Examples of such factors are the user's inability to articulate his/her knowledge about the necessary systems requirements (Boland, 1978), the developers' inability to elicit requirements from the users and follow those requirements in systems design and development (Davis, 1982), and stickiness of knowledge transfer between users and developers (Joshi and Sarker, 2002, Joshi et al., 2004). However, in spite of this realization, only little research has focused on knowledge manipulating activities associated with ISD process (e.g., Kähkönen and Abrahamsson, 2003).

To this end, the objective of this paper is to use Tuomi's knowledge creation model (Tuomi, 1999) as a "kernel" theory for the perspective aspects of ISD process. These perspective aspects include a description of procedures and guidelines for system development (Walls et al., 1992).

The remainder of this paper is organized as follows. In the next section, the knowledge-related problems in ISD process are discussed. The following presents a brief introduction of Tuomi's knowledge creation model (Tuomi, 1999). The application of Tuomi's knowledge creation model to the ISD process is then described. The paper then concludes by discussing the significance and contribution of this work, as well as the possible areas of future research

KNOWLEDGE-RELATED PROBLEMS IN INFORMATION SYSTEMS DEVELOPMENT PROCESS

System Development Knowledge

The successful execution of ISD process requires manipulating a complex body of knowledge, i.e., system development knowledge (SDK). This knowledge involves at least two types of knowledge:

- Application domain knowledge (ADK) (Iivari et al., 2001), and
- ISD methodology knowledge (ISDMK) which includes technical know-how, as well as knowledge regarding IS project management (Kirsch, 2000, Iivari et al., 2001).

Application domain knowledge is the knowledge necessary for the proper identification and description of requirements. For this, one needs two kinds of knowledge: knowledge about the constituents of domain, i.e., the *subject world* (domain ontology) and knowledge about typical activities performed in this domain or the *usage world* (the environment within which the system is being used) (de Oliveira et al., 2004, Mylopoulos, 1992). However, large part of this knowledge is tacit as organizations possess "complex system of shared information, including abstract models of reality and methods of problem-solving related to technology, which is not formalized but is created spontaneously among work group members and is used by group members to support the performance of work tasks" (Baba, 1990, p. 58). In addition to other forms of tacit knowledge, such as theories-in-use (Schön, 1988, Argyris and Schön, 1978), organizations may also have emergent knowledge which lie in the social structure and organizational interaction. Several researchers recognize the crucial role of application domain knowledge in information system development (Glass and Vessey, 1992, Blum, 1989, Vessey and Conger, 1993, Khatri et al., 2003).

On the other hand the dominant approach underpinning many methodologies can be characterized as what Schön (1983) calls "technical rationality": situations in practice can be scientifically categorized, problems are firmly bounded, and they can be solved by using standardized principles. However, it is not possible to have full knowledge about the problem (and thus the applicable method) beforehand, nor can predefined method knowledge cover all possible situations (Tolvanen, 1998). As a result, system development can not be completely carried out by following pre-defined methods. In fact, considerable part of developers' knowledge of ISD is based on what Schön (1983) calls "reflection-in-action", i.e., reflection on the situations in which developers find themselves, rather than being found solely by using predefined methods. Moreover, ISD process has aspects of both science and craft (Ebert, 1997). In addition to the craft-based knowledge such as cases and patterns, tacit and embedded knowledge of ISD underscore its nature as a craft (Ebert, 1997). In fact the lack of understanding of the tacit component of system development knowledge would explains the low acceptance and use of methodologies, and why successful ISD efforts can be carried out a-methodically (Baskerville et al., 1992) without the use of any "explicit" method.

The Symmetry of Ignorance in ISD

Complex design problems, such as information systems development, require more knowledge than any one single person can possess, and the knowledge relevant to a problem is often distributed and controversial. In the case of ISD process, system development knowledge is distributed among many stakeholders. Two main groups of ISD stakeholders can be identified: users and developers. This distribution of system development knowledge leads to a *symmetry of ignorance* (Rittel, 1984), in which each group of stakeholders have only a part of the knowledge required to develop a system. Users are domain experts who understand, to certain extent, the practice (they know implicitly *what* the system is supposed to do) and system developers, to certain extent, know the technology (they know *how* the system can do it). Users lack the knowledge about the technological possibilities that is necessary for envisioning how their current work practices might be changed. A consequence of difficulty envisioning is that system requirements appear to fluctuate (Curtis et al., 1988). In other words, as users learn more about the technological possibilities, their requirements change. On the other hand, developers have certain knowledge of how to build IT-based systems, but they are typically not experienced in the work practices of the application domain. This "thin spread of application domain knowledge" (Curtis et al., 1988, p. 1271) can result in design errors when the developers do not have the knowledge to interpret the user's requirements. This distribution of knowledge results in a so-called symmetry of ignorance between developers and users (Rittel, 1984).

The Knowledge-Related Problems in ISD Process

Based on the discussion in the previous sections the knowledge-related problems in ISD process can be categorized as follows:

The tacitness of application domain knowledge

- The tacitness of users' knowledge about system's requirements
- The tacitness of the relevant organizational knowledge

The tacitness of ISD methodology knowledge

- The tacitness of developers' knowledge about which steps of ISD to select and how to apply them in a specific situation and organizational settings

The symmetry of Ignorance in ISD

- Ignorance of type I: the developers' lack of knowledge about application domain.
- Ignorance of type II: the users' lack of knowledge about technological possibilities that is necessary for envisioning how their current work practices might be changed.

TUOMI'S KNOWLEDGE MANAGEMENT MODEL

Several models of organizational knowledge creation have been suggested. The Nonaka-Takeuchi five-phase model is an example (Nonaka and Takeuchi, 1995). However, the 5-A model proposed by Tuomi (1999) was chosen since it reinterprets and extends Nonaka-Takeuchi model especially in the following areas:

- *Communities of practice:* It explains knowledge creation in situations where multiple communities of practice are involved (Tuomi, 1999). In the case of ISD, there are at least two communities of practice involved: users, which represent the domain-specific community of practice and the developers, which represent ISD community of practice.
- *Its action-orientation:* Organizational knowledge is always anchored to business things toward which thought or action is directed or is communicated by the members of the firm (Hislop et al., 2000, Abou-Zeid, 2002). Moreover, according to Collins (Collins, 1974), knowledge is a capability and thus creates the capacity to do something.
- *Multi-level:* An important feature of Tuomi's model is the way it has integrated both individual and social aspects of knowledge generation. It is, therefore, "scale invariant" (Tuomi, 1999, p.341).

Tuomi's 5-A Model is a cyclic model consists of five basic knowledge-manipulating activities:

- Three activities of knowledge generation, namely: *articulation*, *anticipation* and *appropriation*.
- The activity of knowledge *accumulation*
- The *action* activity.

According to Tuomi, articulation and anticipation can generate new knowledge while appropriation generates knowledge which exists in the society but which is new to the learner. The activity of accumulation refers to the fact that some kind of memory must exist in order to enable learning. The concept of action ties all of the knowledge-manipulating activities.

The first knowledge-manipulating activity, *articulation,* is the activity in which some entity's (individual and group) tacit knowledge is externalized. At the individual level articulation includes concepts, metaphors and stories. At the community level it reveals in development of collective concepts, tools-in-use and practices. The second knowledge-manipulating activity, *anticipation,* is the activity in which an entity (individual and group) creates a model of a world. The tension between the anticipated and observed world may produce new knowledge. It may confirm the model or break it down and lead to a new, better model. The third knowledge-manipulating activity, *appropriation*, is an activity where the learner acquires knowledge already existing in the organization. Appropriation generates knowledge that is available within the organization but which is new for the focal learner. The fourth knowledge-manipulating activity, *accumulation*, refers to the fact that some kind of memory must exist in order to enable learning. In this activity the articulated knowledge can be stored in many forms. At the individual level such forms includes models, habits, history and abstractions. At the community level, knowledge is accumulated by utilizing external cognitive tools such as systems of concepts, paradigms, tools, documents, and social practices. Finally, a*ction* is the ultimate goal of knowledge creation. Action may be both internal and external. While internal action is guiding the individual acting, external action is directed towards others.

KNOWLEDGE MANAGEMENT PERSPECTIVE OF ISD PROCESS

The phases in ISD cycle can vary radically depending on which development methodology has been chosen. However, by viewing a methodology as a problem-solving mechanism three major phases, which are shared by all methodologies, can be identified, namely: analysis, design, and implementation (Jayaratna, 1994, Wand et al., 1995).

The main goal of analysis phase is to transform a perceived real-world system into conceptual models of that system (Wand et al., 1995). Such conceptual models aim at describing *what* the system is doing and what it should be doing to meet users' requirements (Burch and Grudnitski, 1989). The main challenge in this phase is twofold. First is the tacit component of users' knowledge about system's requirements. Second is the developers' lack of knowledge about application domain. Therefore, two knowledge-manipulating activities are necessary for successful execution of the activities in this phase: articulation and appropriation. Articulation is important for three reasons:

1. articulation causes users to begin to move from vague mental conceptualizations of their requirements to a more concrete representation;
2. articulation provides means for developers to appropriate the articulated users' requirements, to interact with, react to, negotiate around, and build conceptual models of that system upon the articulated requirements; and

3. articulation provides an opportunity to create a common language of understanding between both communities: users and developers. The use of external representations, or conceptual models, (Bruner, 1996) serves to focus discussions upon relevant aspects of the problem being studied and allows users to engage in a conversation with the developers (Schön, 1983).

In addition, users need to anticipate what the prospective system should do to meet their requirements.

The main goal of design phase is to transform the conceptual models of the subject world, into a model of the information system that describes *how* the system is developed to meet users' requirements (Wand et al., 1995, Burch and Grudnitski, 1989). One of challenges in this phase is the ability of developers to determine which steps of ISD to select and how to apply them in a specific situation. This ability depends on their experience-based tacit knowledge and on their knowledge about the application domain (Jayaratna, 1994). Another challenge is how to integrate various perspectives emerging from the analysis phase in order to synthesize the desired solution. Therefore, three knowledge-manipulating activities are needed, namely: articulation, accumulation and action. Articulation during design phase involves the explication of tacit component of pertinent organizational knowledge such as actual work practice. Moreover, as knowledge about specific solution synthesis is aqcuired through situated practice, that is, "learning by doing" (Gasson, 1999), developers need to explicate their newly generated knowledge. The newly articulated knoweldge has to be then accumulated and used as the basis for developers' next (internal) actions.

Finally, the main goal of implementation phase is the realization of the model of the information system within the context of "usage world", i.e., the organizational environment within which IS will be used. Among the knowledge-related problems that would affect the outcome of this phase is the users' lack of knowledge about technological possibilities that is necessary for envisioning how their current work practices might be changed. Moreover, several forms of tacit component of organizational knowledge, such as shared values, beliefs and political interests of users, may affect successful implementation of IS (Martinsons and Chong, 1999). As in the design phase three knowledge-manipulating activities are needed to deal with these problems, namely: articulation, accumulation and (external) action. Table (1) summarizes the main knowledge-related problems in each ISD phase together with the required knowledge manipulating activities represented in terms of the following triad: *Actors involved (Subject) –Knowledge-Manipulating Activity-Object*.

Table 1. Knowledge-Related Problems and Knowledge Manipulating Activities in ISD

ISD Phase	The Main K-Related Problems	Examples of Associated K-Manipulating Activities
Analysis	The tacitness of users' knowledge about system's requirements Ignorance of type I: the developers' lack of knowledge about application domain.	▪ Users- Articulation – Articulated Requirements ▪ Developers – Appropriation- Articulated Requirements
Design	The tacitness of organizational knowledge The tacitness of developers' knowledge about which steps of ISD to select and how to apply them in a specific situation and organizational settings	▪ Users/Developers- Articulation- Articulated relevant organizational knowledge ▪ Developers- Articulation- Reflection-in-action ▪ Developers- Accumulation- e.g., Design documentation ▪ Developers- (Internal) Action – situated design guidelines
Implementation	The tacitness of organizational knowledge Ignorance of type II: the users' lack of knowledge about how their current work practices might be changed	▪ Users/Developers -Articulation- e.g., values-in-action ▪ Users -Appropriation- e.g., user training ▪ Developers - (External) Action - Implemented application

CONCLUSION

This paper attempted to develop a knowledge management perspective of ISD process based on theoretically grounded model of knowledge creation. There are several advantages of this perspective. First, it explicates the knowledge-related problems associated with ISD process. Second, it shifts the focus from the myriad of features of countless methodologies to the most fundamental ingredient of all of them, namely: knowledge. It was also underscored that the successful ISD process always presupposes tacit knowledge. Therefore, tacit knowledge associated with ISD should be appreciated as much as explicit knowledge. The interplay of the explicit and tacit and embedded organizational knowledge also forms a stimulating research topic.

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