Thesis Summary:

Developing Effective Knowledge Management Systems

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Abstract

This paper examines possible shortfalls in the design of Knowledge Management Systems (KMS) and proposes a way to design more effective KMS using meta-knowledge. We develop a theoretical framework for identifying the best design features necessary to support effective KM in organizations. We then apply this framework to identify possible weaknesses of 40 KMS in four different categories of tools: content management, knowledge sharing, knowledge retrieval, and general KMS. Our findings show that one of the problems in the design of existing KMS is the lack of a unified approach to meta-knowledge (knowledge about the knowledge). In the second part of the paper we propose an empirical evaluation of users' meta-knowledge requirements using the Delphi methodology as well as conjoint analysis. We hope that our findings can be used to support the development of more effective KMS.

Keywords: Knowledge Management Systems; Meta-Knowledge; Conjoint analysis

1. Introduction

Knowledge Management Systems (KMS) are technologies that support Knowledge Management (KM) in organizations, specifically - knowledge generation, codification, and transfer (Ruggles, 1997). The use of KM in organizations is now widely recognized and expected to be an important part of organizational practices in the future (Gartner Group, 2002). Moreover, in a 2000 survey on Knowledge Management practices (KPMG, 2000) 81% of the companies surveyed engaged in some KM practices or initiatives, all using technology to support them.

However, the KPMG survey also found that KMS often do not support effective KM. The reason is said to be a lack of understanding of users' requirements from the KMS (KPMG, 2000). To a considerable extent this reflects the lack of an overall understanding of organizational requirements (Alavi, 2000). In other words, existing KMS may not be designed to provide all the functionalities required by organizations for effective KM.

The objective of this study is to understand why KMS are not as effective as expected and to propose ways to improve them. The research questions are:

1. What are the shortfalls of existing KMS?
2. How can we create more effective KMS?

We begin this paper by examining organizational requirements from KMS and identify the main functionalities they need to provide (section 2). In section 3 we examine whether existing systems provide these functionalities and identify possible shortfalls of these systems. Finally, in section 4, we propose a way to overcome some of these shortfalls by enhancing the design of KMS.

2. Background - Organizational KM Needs

We derive organizational needs from KMS by looking at the processes supporting KM in organizations (Alavi and Leidner, 2001). These processes imply *required functionalities* that a KMS should provide to enable effective KM. We develop our argument by looking first at the most general KM activities in organizations. We then identify the processes that support these activities and the functionalities required to support these processes. Finally, we examine the most suitable design for KMS in order to provide these functionalities.

There are three main KM activities in organizations, namely – knowledge **generation**, knowledge **sharing,** and knowledge **codification** (Davenport and Prusak, 2000). Nonaka (1994) explains these activities in a comprehensive theory about organizational knowledge creation based on interactions between tacit (highly personal) and explicit (formalized) knowledge. The process begins with the enhancement of an individual's tacit knowledge through hands-on experience, supporting the generation of knowledge. *Socialization* then follows, involving the transfer and sharing of tacit knowledge between individuals. Dialogues allow the conceptualization of the tacit knowledge and trigger *externalization,* the transformation of knowledge from tacit to explicit. Finally, the knowledge is *combined* with existing knowledge and *internalized* (codified). The processes described in Nonaka's model can support all three KM activities in more than one way as depicted in Figure 1[1].

[1] We exclude individual learning from the analysis since it is highly tacit and less dependent on technology.

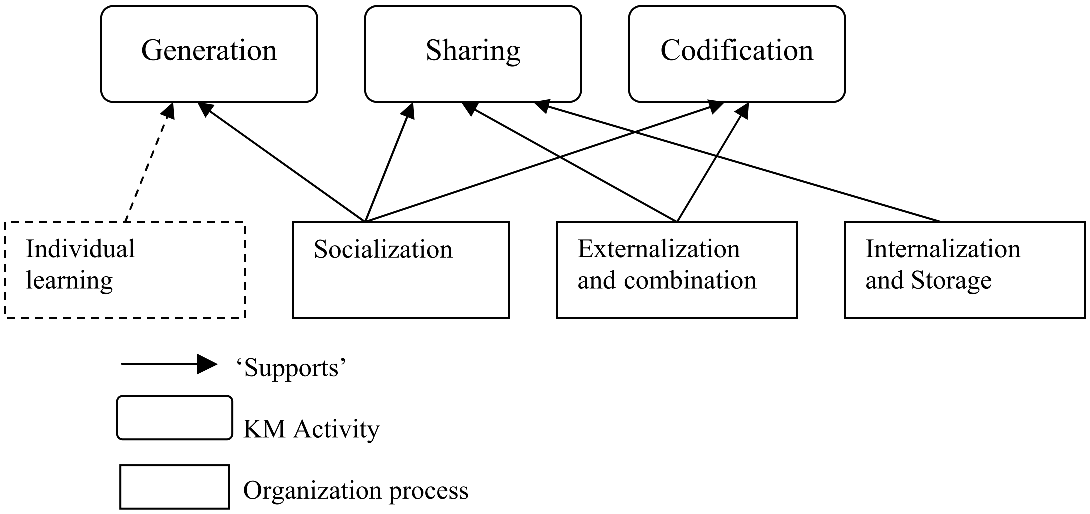

Figure 1: KM activities and supporting processes

Socialization. Socialization supports knowledge generation by supporting interactions and exchange of ideas between individuals. It supports knowledge sharing between individuals in a similar way. This role of socialization is discussed in greater detail in literature that examines 'communities of practice' (Brown and Duguid, 1991, 1998) that enable knowledge to travel efficiently within organizations. Finally, socialization supports the storage of knowledge since often knowledge is "stored" in individuals' memories and socialization serves to transfer knowledge between individuals.

Externalization and Combination. Externalization enables the transformation of knowledge from tacit to explicit. This transformation is important for knowledge sharing since explicit knowledge is easier to share, and for knowledge codification that requires transferring tacit knowledge into explicit forms.

Internalization and Storage. The storage of organizational knowledge is generally supported by organizational memory (Walsh and Ungson, 1991). Organizational memory is "the means by which knowledge from the past is brought to bear on present activities, thus resulting in higher or lower levels of organizational effectiveness” (Stein 1995:22). Storing knowledge in organizational memory supports knowledge sharing by preserving knowledge in a central location.

From these KM processes we deduce seven *functionalities* required from a KMS to support the three KM activities of generation, sharing, and codification:

SO1[2] – support *knowledge generation* by interactions between individuals and communities (e.g. brainstorming)
SO2 – support *knowledge codification* through conversations (e.g. discussion forums)
SO3 – support *knowledge sharing* between users (e.g. by email)

EC1 – support *knowledge codification* and combination with other knowledge (e.g. electronic documentation)
EC2 – support *knowledge sharing* by transforming tacit knowledge to explicit (e.g. explaining best practices)

ST1 – support *knowledge sharing* by managing organizational memory (e.g. content management systems)
ST2 – support *knowledge sharing* by facilitating retrieval of knowledge from memory (e.g. search engines)

Next we identify the best design features that can provide these functionalities.

2.1 Required Design Aspects

Based on KMS literature we propose three design aspects to support the KMS functionalities: (1) the network design to support sharing, (2) an ontological base to provide a shared language, and (3) meta-knowledge (knowledge about the knowledge) to support organizational memory. These aspects are described below as well as in Figure 2.

[2] SO - socialization; EC – externalization and combination; ST – storage

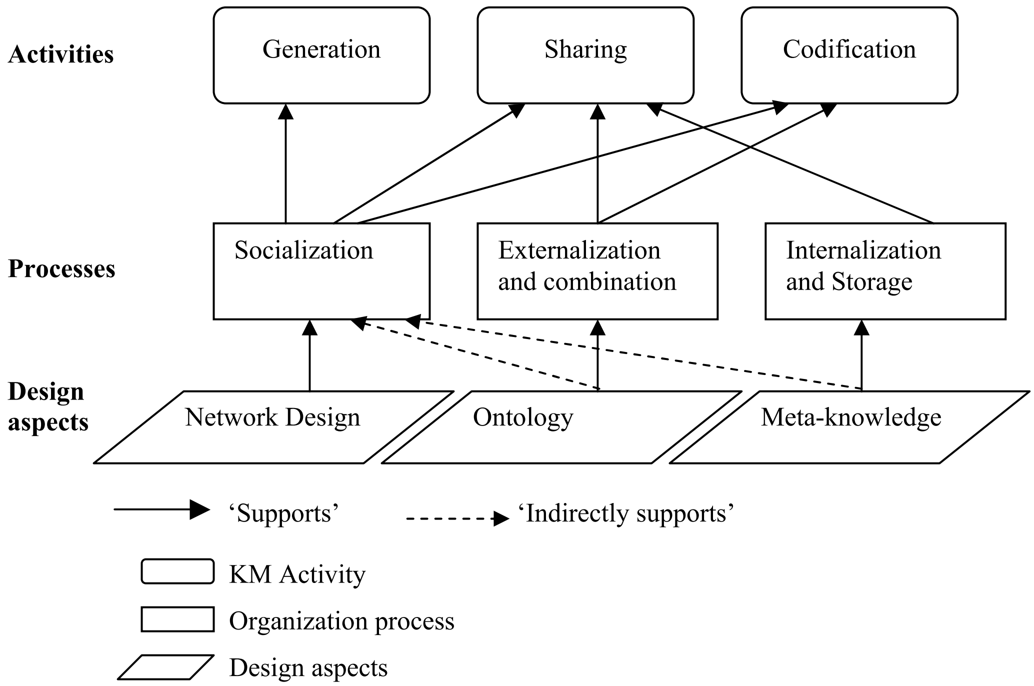

Figure 2: Required design aspects of KMS

Network design. Knowledge networks are intended to create links between individuals to facilitate knowledge sharing (Alavi, 2000). We argue that the network design can best support the socialization process by connecting knowledge seekers to knowledge sources, as opposed to the repository model – e.g. knowledge bases – that is not designed to encourage socialization.

Organizational Ontology. An ontology is a specification of objects, concepts, and other entities that exist in a domain, and the relationships among them (Gruber, 1993). Organizational ontologies provide a common language for communications (O'Leary, 1999). Therefore, an ontologically based KMS can provide tools for externalizing tacit knowledge. In addition, using an ontology can support socialization by providing a language for communicating across the organization.

Meta-knowledge. Meta knowledge can support effective management of organizational memory (Plant and Gamble, 1997; Schwartz, 1999). This is similar to maintaining meta-data about data stored in databases or maintaining information about items stored in physical inventories. An additional support for the use of meta-knowledge comes from epistemology literature (Lehrer, 1990) where information about the knowledge is required by users of the knowledge to justify its use. Meta-knowledge mainly supports the internalization and storage of knowledge but can also support socialization by providing users with information about knowledge and knowledge sources.

Table 1 summarizes our theoretical analysis and demonstrates how each of the design aspects supports the three KM activities through the seven functionalities. The specific algebra of Table 1 includes direct effects, for example the *Network design* supports the *generation* of knowledge through its support of socialization, in particular through *interactions* (SO1). Indirect effects, for example, the Ontology aspect supports knowledge generation though interactions (SO1) but it does so *indirectly* through its support of externalization of tacit knowledge (EC2). Indirect effects are represented using squared brackets (SO1[EC2]). Combined effects, for example, the effect of ontology on codification is through its support of the transformation of tacit to explicit knowledge (EC2). This effect is combined with discussions (SO2) and represented as SO2*EC2. This combination facilitates the codification of the knowledge (EC1) and thus we indicate EC1[SO2*EC2]. Finally, two separate effects can exist, for example – meta-knowledge supports sharing by supporting both the management of organizational memory (ST1) and the retrieval of knowledge (ST2).

KM activities / Evaluation Criteria	**Generation**	**Codification**	**Sharing**
Network Design	SO1	SO2	SO3
Ontology Based	SO1[EC2]	EC1[SO2*EC2]	EC2
Meta-knowledge	SO1[ST2]	SO3[ST2]	ST2, ST1

SO1 – direct effect; [SO1] – indirect effect; SO1*SO2 – combined effect; SO1, SO2 – two separate effects

Table 1: How design aspects of KMS support KM activities

Based on Table 1 we can now turn to analyze the shortfall of existing KMS.

3. Work done so far - Shortfalls of Existing KMS

In order to answer our first research question about the shortfalls of KMS we evaluated existing KMS based on the theoretical framework. We developed two specific evaluation measures. First, we examined the *number of KM processes supported by existing tools.* That is, how many of the required functionalities can be provided by each tool. Second, we examined the *effective support of systems in organizational processes.* We defined ***effective support*** as the ability of a KMS to support a specific process using the most suitable design for this process. For example, a network-based tool effectively supports socialization but not so much codification of knowledge. To support codification effectively the tool would have to be ontology-based. The best designs for each process are presented in Figure 2.

We examined 40 KMS from four different categories. The tools examined were listed in KM World's top 100 KMS[3]:

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[3] www.kmworld.com. A list of the tools evaluated is provided in Appendix A.

1. Content management tools: tools that offer abilities to integrate, classify, and codify knowledge from various sources.
2. Knowledge sharing tools: tools that support sharing between people or other agents.
3. Knowledge search and retrieval systems: systems that enable search and retrieval and have some knowledge discovery abilities.
4. General KMS: systems that propose an overall solution for a company's KM needs.

The evaluation of tools consisted of three stages. We first classified each tool into one of the four categories; we then identified the specific KM processes and functionalities (i.e. socialization, externalization, and storage) the tool aims to support. We deduced the supported functionalities by analyzing information provided on the vendor's website. An example for this deduction process is presented in Appendix B; finally we identified each tool's design specifications based on the three design aspects.

To measure how well KMS support the KM processes we recorded the percentage of tools in each category that supported the different functionalities. This information is presented in Figure 3. To measure effective support we examined the number of tools in each category that used the most suitable design to support a specific functionality out of the total number of tools that purported to support this functionality. For example, 85% of the knowledge sharing tools effectively support socialization. This means that out of all the knowledge sharing tools that purport to support socialization 85% are based on the network design, which we identified as the most suitable design to effectively support socialization. Effective support is presented in Figure 4.

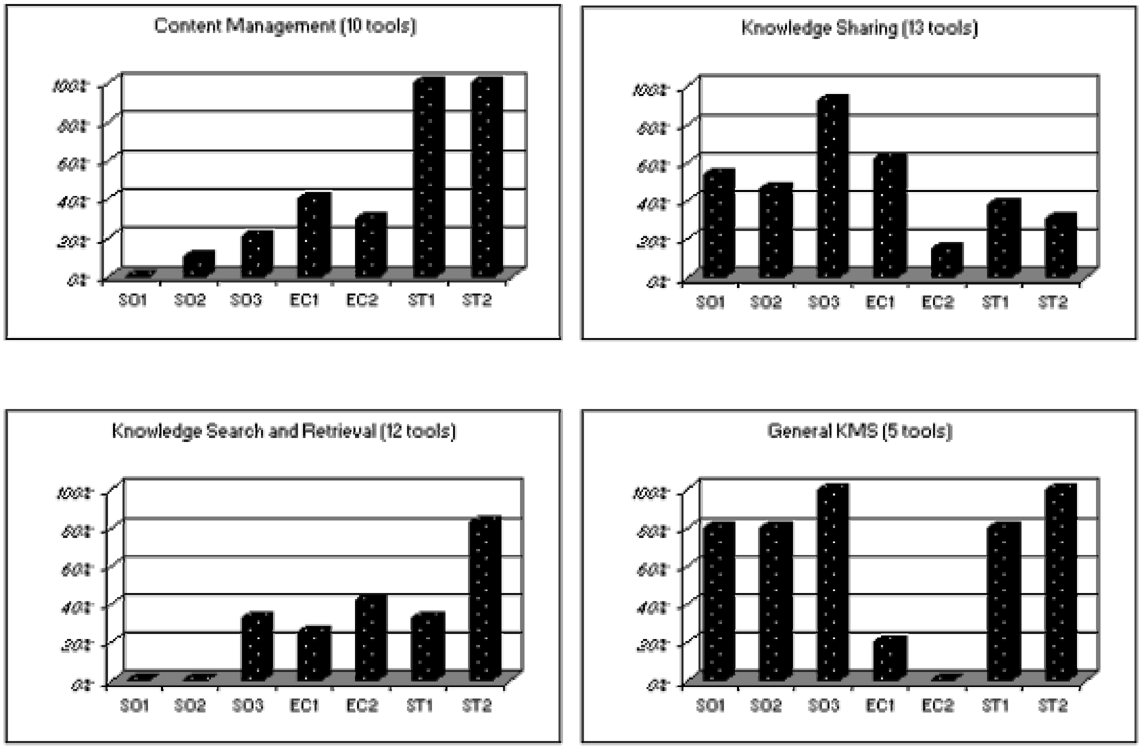

Figure 3: Percent of tools that support each KM functionality (by category)

Legend:

SO1–	support *knowledge generation* by interactions between individuals and communities (e.g. brainstorming)
SO2 –	support *knowledge codification* through conversations (e.g. discussion forums)
SO3 –	support *knowledge sharing* between users (e.g. email)
EC1 –	support *knowledge codification* and combination with other knowledge (e.g. electronic documentation)
EC2 –	support *knowledge sharing* by transforming tacit knowledge to explicit (e.g. explaining best practices)
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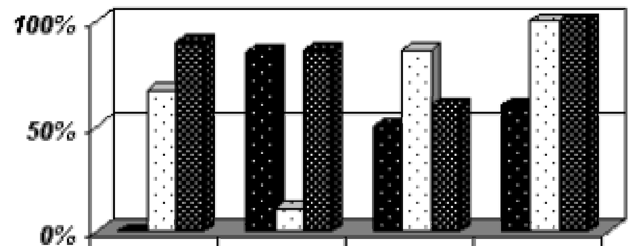

	Content Management	Knowledge Sharing	Knowledge search and	General KMS
■ Socialization	0%	85%	50%	60%
□ Externalization & combination	67%	11%	86%	100%
■ Internalization & Storage	90%	86%	60%	100%

Figure 4: Percent of tools that effectively support KM processes

Our findings show that KMS are able to support many organizational KM requirements. However, most tools cover a limited number of functionalities (see Figure 3) and organizations may need to incorporate several tools to attain a general KM solution. This may cause difficulties in creating an integrated KM environment.

Figure 4 demonstrates that tools are designed to effectively support at least one of the KM processes. That is, that tools are built based on the most suitable design for their intended use. For example, Figure 3 shows that content management tools focus on supporting the two storage activities and – according to Figure 4 – effectively support these activities. Nevertheless, we identify two specific design problems that may inhibit effective use of KMS. First, most tools do not use an organizational ontology but more limited linguistics tools (e.g. taxonomies). Second, there is no unified approach to meta-knowledge. That is, the content of meta-knowledge used by different tools varies substantially.

These three problems should be resolved in order to attain more effective use of KMS. However, in this study we focus only on identifying required meta-knowledge, the least studied of the three. Meta-knowledge is important for the management and retrieval of knowledge from organizational memory and supports the sharing and use of organizational knowledge. In addition, by supporting socialization, meta-knowledge is important for all three KM activities. Unfortunately, it is not clear from the literature *what meta-knowledge* can support effective KMS. Some approaches propose 'technical' meta-knowledge such as ontologies or problem-solving methods (Kalfoglou et al, 2000, Plant and Gamble, 1997). A different approach derives meta-knowledge from the user's perspective. For example, using meta-cognitive knowledge - knowledge of person, task, and strategy variables (Livingston, 1997). Finally, in the Persuasion literature, meta-knowledge includes evaluative measures such as source credibility (Hovland et al, 1953).

In this study our goal is to identify the specific components of meta-knowledge that can increase the effectiveness of KMS. Since the requirements of the users of a system play an important role in determining its effectiveness we investigate the meta-knowledge requirements of potential users of the KMS.

4. Future work - An Empirical Examination of Meta-Knowledge

We have associated meta-knowledge with organizational memory. Therefore, to identify required meta-knowledge we adopt the theoretical basis of another collective memory system, namely - ***transactive memory***. Transactive memory is based on the distinction between *internal* and *external* memory encoding. For example, when I memorize a book I internally encode the knowledge in the book. However, if I only remember the title and location of the book, then the book serves as an external memory to me. In transactive memory systems, individuals play the role of external memory for other individuals who – in turn – encode *meta-memories* (memories about the memories of others) to locate this knowledge in the future (Wegner, 1987). For example, students in a 'Systems Analysis and Design' course know that the professor is a source of knowledge related to this topic.

Benefits from transactive memory have been identified in memory retrievals in dating couples (Wegner, 1987) as well as in the performance of small groups (Moreland et al, 1996). Therefore, in this work we wish to draw on these benefits and design organizational memory as an organization wide transactive memory system.

Wegner (1995) proposes that in transactive memory systems individuals encode the *label* (subject) of the knowledge and its *location*. For example, in the previous paragraph, the label of the knowledge is 'Systems Analysis and Design' and the location is the professor. In addition, individuals have some perceptions about their own and others' (e.g. the Professor's) expertise regarding this topic (Liang and Rau, 2000). When constructing an organization wide transactive memory system we imitate this required meta-memory using meta-knowledge as depicted in Figure 5.

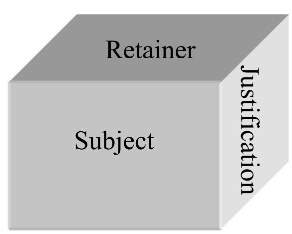

Figure 5: Dimensions of meta-knowledge

We refer to a specific piece of knowledge as a conceptual cube that can be represented by its meta-knowledge. Apart from the benefits derived from facilitating the retrieval of knowledge from organizational memory, this representation of knowledge through meta-knowledge dimensions also supports the codification and capturing of tacit knowledge, a main difficulty in the design of KMS.

Following the transactive memory literature, the first dimension of meta-knowledge is the subject of the knowledge. A second dimension is the retainer of the knowledge[4]. Finally, the third – and most tacit – dimension is the *justification* of the knowledge. This pertains to perceptions that individuals hold concerning other memory retainers – for example their perceived expertise – and that based on them individuals decide to retrieve a specific knowledge to a specific task. We examine the exact nature of justification below.

4.1 The Research Model

The concept of justification requires that knowledge be derived from reasoning and not guessing (Lehrer, 1990). To this extent, a reliable source is also considered proper justification. For example, you are justified in believing it is raining outside without actually going outside but based on the TV weather report. Therefore, justification is based on both characteristics of the knowledge itself and of the knowledge source. While justification can be deduced from logical argumentation, in this study we are looking for specific justification components *held by individuals* about external knowledge (similar to transactive memory). Examples for such characteristics are perceived source credibility (Hovland et al, 1953) or the currency of the knowledge (Duffy, 2000). Our hypotheses about the components of justification are:

H1: Justification of knowledge includes characteristics of the source of the knowledge.

H2: Justification of knowledge includes characteristics of the knowledge itself.

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[4] We refrain from using the word "source" to distinguish the source (or creator) of the knowledge from other retainers (that simply hold the knowledge at a certain point).

Note that we do not hypothesize about specific components of justification but about the *type* of these components. The reason is that specific components may depend on several individual and situational characteristics. We discuss these briefly below:

Individual Expertise. Expertise is the possession of a substantial body of knowledge and procedural skills (Nelson et al. 2000). There are several differences between experts and novices (Bedard et al. 1993): experts own more knowledge and more meta-knowledge; experts have stronger sense of what is relevant; experts possess more and stronger links between concepts; and, experts rely on deep features such as principles or procedures. We therefore expect that experts will have more articulated justification requirements than novices.

H3: Required components of justification will be affected by a person's expertise.

Organizational characteristics.

Knowledge Intensity. Knowledge intensity is the extent to which a firm depends on its knowledge as a source of competitive advantage (Autio et al, 2000). Knowledge intensive companies will allocate more resources to Knowledge Management (Davenport and Smith, 2000). Therefore, such organizations may have supporting technologies for KM that dictate users' justification requirements.

Formalization. Formalization is the extent to which rules, procedures, instructions, and communications are written in the organization (Pugh et al, 1968). Daft and Lengel (1986) note that formalization provides a knowledge base for employees to respond to routine organizational phenomena, such as information processing and use. Formalization can affect users' justification requirements by providing guidelines for what measures are acceptable to the organization.

H4a: Required components of justification will be affected by the level of knowledge intensity.

H4b: Required components of justification will be affected by the level of formalization.

Task Equivocality. Equivocality is the multiplicity of meaning conveyed by information and is associated with confusion and lack of understanding (Lim and Benbasat, 2001). Daft and Macintosh (1981) found a negative relationship between task equivocality and task analyzability as well as between equivocality and the amount of task information processed. Therefore we suspect that equivocality may affect justification.

H5: Required components of justification will be affected by the task equivocality.

Based on these hypotheses, the research model is presented in Figure 6:

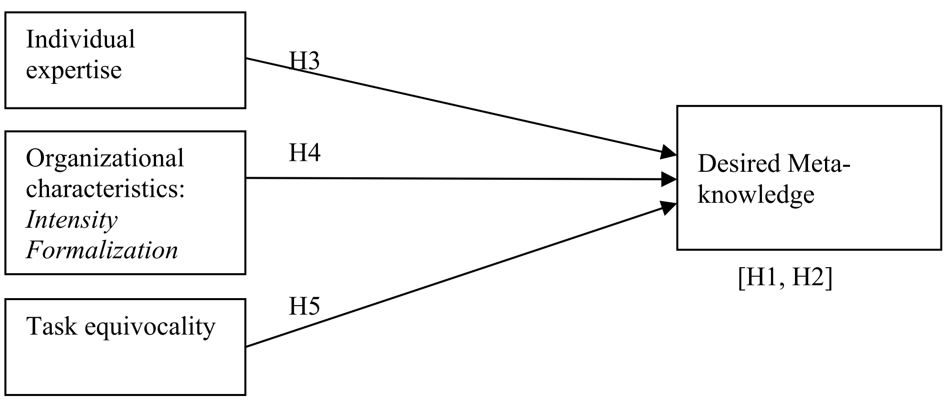

Figure 6: The research model

Next we turn to describe the research methodology applied in our study.

4.2 Methodology

The chosen methodology for identifying characteristics of knowledge and knowledge sources is conjoint analysis. Conjoint analysis is a multivariate technique used to understand respondents' preferences towards products or services. As the name suggests, it is used to understand the *joint effect* of two or more independent variables on the ordering of a dependent variable (Green and Rao, 1971). Conjoint analysis is a *de-compositional* approach in the sense that it relies on a basic assumption that respondents' preferences toward a product can be decomposed to derive the values they place on specific attributes of the product (Hair et al, 1992). Other methods such as regression analysis are *compositional* – they derive the dependent variable by composing the values provided for the independent variables.

Conjoint analysis was first developed in the 60s and has since grown in popularity. It is used to evaluate acceptance of new products, identify new market shares, or predict consumer behaviour (Green et al, 2001, Wittink and Cattin, 1989). Some examples for applications of conjoint analysis are the design and evaluation of a new product/technology (a study of EZ-Pass in the US by Vavra et al, 1999), evaluation of services (a study of the Mariott Courtyard Hotels by Wind et al, 1989), and evaluation of consumers' perceptions. (For example, Gordon and Lima-Turner (1997) evaluate consumers' attitudes towards Internet advertising. Soo (1999) examines risk perceptions of online shoppers).

The choice of conjoint analysis for this study is derived from the study's objectives: (1) to evaluate the values that individuals place on various characteristics of knowledge and knowledge sources in making knowledge-use decisions (H1, H2), and (2) to identify differences in the values placed by specific groups or segments (H3-H5).

There are two major steps in designing a conjoint analysis study (Hair et al, 1992): identifying relevant attributes and possible values of attribute, and designing the conjoint experiment. The structure of the rest of this section will follow these two steps.

4.3 Identifying relevant attributes – a Delphi study

The identification of the relevant attributes and attribute levels is an important stage in the conjoint study (Hair et al, 1992). Common methods for deriving the list of relevant attributes - also known as **'factors'** - in conjoint studies include personal interviews, expert judgment, group interviews, or computerized methods (Cattin and Wittink, 1982; Green and Srinivassan, 1990). We select the Delphi method that includes many of the above.

Delphi is a method for exploring ideas or producing information for decision-making. It aims to obtain a consensus of opinions from a group of experts using repeated questionnaires and controlled feedback. The method was first developed in the 1950s to improve forecasting methods but today is also used to achieve a group consensus about the relative importance of issues (Schmidt, 1997). Some examples for such Delphi studies include identifying the most critical issues facing IS executives (Brancheau and Wetherbe, 1987), identifying typical project risk factors (Schmidt et al, 2001), and characterizing organizational knowledge resources (Holsapple and Joshi, 2000).

The Delphi method is most useful when one cannot use precise analytical techniques, when the problem is new and unexplored, or when the problem requires the exploration and assessment of numerous issues (Adler and Ziglio, 1996). The results of a Delphi study can serve to ensure that all major possible options concerning a particular issue have been investigated. These characteristics of the Delphi method make it useful for identifying the set of attributes involved in the evaluation of knowledge and knowledge sources.

The Delphi process employed in this study is described in Figure 7. The main question we ask participants is: *"In your opinion, what are the most important characteristics of a knowledge source and the most important characteristics of knowledge?"*

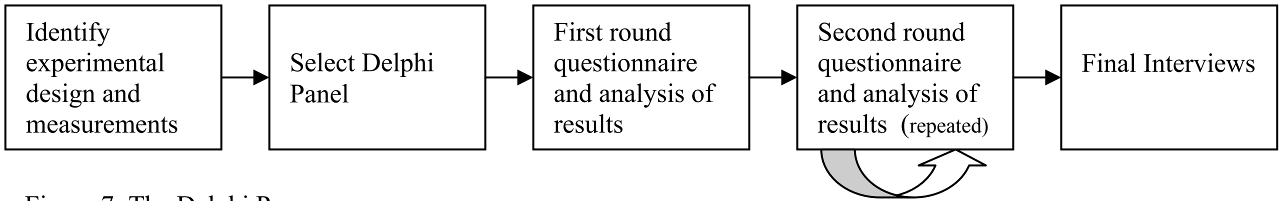

Figure 7: The Delphi Process

Experimental design and measures. In our theoretical analysis we identified four factors that may affect the required characteristics of a selected knowledge source. These factors are individual expertise, organizational knowledge intensity, organizational level of formalization, and task equivocality. In order to ensure that we elicit all the relevant factors in the Delphi study we create some manipulations of these four factors. For example, we ask panel members to refer to specific examples that vary in their level of equivocality. By doing so we ensure that if equivocality indeed affects the required characteristics of knowledge and knowledge sources then participants will provide a wider set of characteristics when considering both low and high equivocality situations. We explain the specific manipulations and measures below.

Knowledge intensity and level of formalization. Knowledge intensity is measured using a seven-point scale developed by Autio et al (2000) (3 items; α=0.85). Formalization is measured using a six-point scale developed by Ferrel and Skinner (1988) (6 items; α=0.75). We will select panel members from different organizations and evaluate the levels of intensity and formalization using these scales.

Individual expertise and task equivocality. Individual expertise is measured as self reported expertise on a five-point scale. Task equivocality is measured using Dennis and Kinney's (1998) seven-point equivocality scale (6 items; α=0.84). To manipulate expertise and equivocality we use three specific examples:

Example 1: low expertise - low equivocality (based on Dennis and Kinney, 1998).

Participants are asked to find an answer to a standard psychology exam question taken from a psychology GRE exam. The average reported expertise for this example in the Pilot study[5] was 1 (low).

Example 2: low expertise - high equivocality (based on Dennis and Kinney, 1998).

Participants are asked to participate in the admissions decision of MBA students to the UBC MBA program. The average reported expertise for this example in the Pilot study was 1.33.

Example 3: high expertise - varying equivocality.

To attain a 'high expertise' example, participants provide their own work related example. Participants also respond to the 6 items equivocality scale (Dennis and Kinney, 1998) to assess the equivocality of the example. Some examples provided in the Delphi pilot study are:

- "I need to know the performance spending levels of other health care organizations in order to compare our performance". The reported expertise for this example was 4 out of 5; the perceived equivocality score was 4.8 out of 7 (high).
- "I need to know about standard practices for managing email in a large corporation". The reported expertise for this example was 3 out of 5; The perceived equivocality score was 5 out of 7.
- "I need to know about techniques for casting concrete in runways". The reported expertise for this example was 4 out of 5; The perceived equivocality score was 4.3 out of 7.

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[5] The complete pilot study is described at the end of this section. Here we just provide some support and explanations for the examples selected.

It is important to note here that the Delphi study is not intended to test the research model. The use of examples and participants from different organizations in the Delphi study is only to gain a more complete set of factors for the conjoint analysis.

Panel selection. The accepted panel size for a Delphi study is 30 (Delbecq et al., 1975). Desired panel members are potential users of KMS. We evaluate participants' knowledge search habits and familiarity with knowledge management to ensure that they are familiar with knowledge search tasks. Panel members are selected from different organizations.

First round procedure. This is a brainstorming round in which participants are asked to provide a list of characteristics of knowledge and knowledge sources that are important to them when searching for knowledge (Schmidt et al, 2001). To ensure the completeness of the list provided in this round, participants are asked to answer the study question for the examples provided as explained above.

Second round procedure. In the second round participants are asked to *rate* the importance of each characteristic on a scale of one to ten, ten being the most important. This round is repeated until consensus is achieved. To verify the consensus of responses Schmidt (1997) proposes the use of Kendall's coefficient of concordance (W). When $W > 0.7$ good consensus exists.

Final interview. The list of characteristics identified in the Delphi study represents the range of attributes (*factors*) that play a role in the individuals' decision process. However, to be able to manipulate these attributes in the conjoint analysis we need to know the values (*levels*) they can have. For example, the factor 'level of education' can have four levels: 'high school or lower, some college, Bachelor's degree, Master's degree or higher'. The purpose of the final interviews, conducted individually with panel members, is to better understand their decision-making process and to identify possible factor levels.

The final interviews can also serve to refine the list of factors and to identify possible correlations between factors. Interattributes correlations affect the parameters estimations in conjoint analysis similar to the problem of multicollinearity in regression analysis. In addition, these correlations can result in 'unbelievable' combinations. For example when two negatively correlated attributes receive high values (e.g. high horsepower and high gas mileage in cars). When two attributes are correlated it is best to create one 'superattribute' that represent the correlated attributes. In the car example this attribute can be "performance" (Hair et al, 1992).

Pilot study. We conducted two pilot studies for the Delphi experiment. The first study included five panel members from the Faculty of Commerce at UBC. The intention of the study was to test the reliability of the technology and to ensure that the questionnaires could be easily understood. A second pilot study was conducted using 10 panel members from the actual sampling population of the Delphi study. The purpose of this study was to retest the questionnaires and evaluate the design of the study. Following the pilot studies we reduced the number of examples in the first questionnaire from three to two and will use random assignment of the first two examples between panel members. That is, in a panel of 30 members, 15 participants will refer to the first example (low expertise-low equivocality) and add their own example and 15 participants will refer to the second example (low expertise-high equivocality) and add their own example. By designing the study this way we reduce the workload on participants and hope to elicit more characteristics.

We are currently recruiting panel members for the Delphi study. The expected result from the Delphi is a rated list of characteristics of knowledge and of knowledge sources that users believe are important for knowledge-use decisions. Combinations of different levels of these characteristics will be manipulated in the conjoint analysis to test our hypotheses.

4.4 Designing the Conjoint Analysis Study

In this section we describe the design decisions involved in a conjoint study. The first decision concerns the administration of the study. We will administer the conjoint analysis as a web-based survey to various organizations.

A conjoint analysis study begins with identifying the relevant *factors* and their *levels.* At the next stage the researcher designs *stimuli* – combinations of different levels of the factors. These stimuli are presented to respondents who are asked to rate (or rank) them according to their preferences. The results are then analyzed using one of a few possible statistical techniques. There are six specific steps/decisions involved in the design of a conjoint analysis (Green and Srinivasan, 1990). They are summarized in Table 2 and explained below.

Step	**Description**
1. Selection of preference model	Identifying the preference structure of respondents
2. Data collection method	Selecting a specific conjoint model
3. Stimulus set construction	Setting the number of stimuli to be used
4. Stimulus presentation	Determining the presentation method: we will not discuss this step here since we are not testing a physical product that can be affected by the use of pictures or other sensory tools.
5. Measurement scales for the dependent variable	Deciding on the use of measurement scale (e.g. ranking vs. rating).
6. Estimation method	Selecting between metric methods (multiple regression); non-metric methods (MONANOVA); and choice-based methods (logit, probit)

Table 2: Steps in designing a conjoint analysis

Selection of preference model. This model represents the preference structure of the respondents and consists of a composition rule and a part-worth relationship. The composition rule describes how respondents combine the separate factor utilities to obtain the overall value of the product. The part worth relationship represents the relationship between different levels *within* the same factor.

The most common composition rule used is the *additive (main-effect) model* in which respondents simply add the separate utilities to attain an overall value of the product (Hair et al, 1992). A different composition rule is the *interactive effects model* in which interactions between two of more factors are possible. Empirical evidence shows that models with interaction terms lead to lower predictive validity (Green and Srinivasan, 1990). We have no strong theoretical argument for the existence of an interaction effect between factors and therefore select the additive model.

There are three possible part-worth relationships in conjoint analysis, shown in Figure 8.

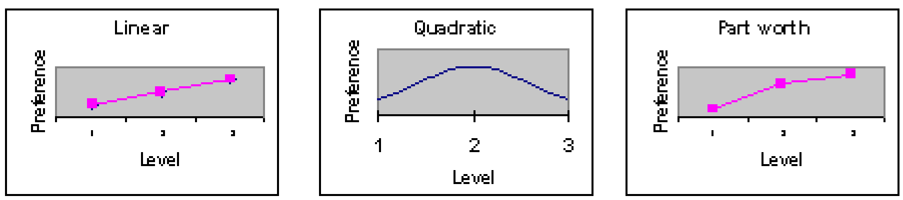


Figure 8: Types of relations between factor levels

The most restrictive – the linear form – assumes a single part worth that is simply multiplied by the level's value. The least restrictive – the separate part worth – allows every level to have its own estimate. A third relationship, the quadratic, or ideal-point, model falls in between the two. The most commonly used relationship is the separate part worth (Green and Srinivasan, 1990) and since it is also the least restrictive one we will use it in this study. The linear and quadratic models can be special cases of this relationship.

Data collection method. The data collection method refers to the method of presenting the stimuli to respondents and the elicitation of preferences. There are three common data collection methods in conjoint analysis: the trade-off method, the full profile method, and hybrid conjoint models. The *trade-off* method presents respondents with two factors at a time and asks to rank the two. It is simple to administer but has many limitations (Green et al, 1988). A much more popular method is the *full profile* method (Green and Srinivasan, 1990, Hair et al, 1992).

In the full profile method respondents are presented with combinations of all the factors and are asked to rank or to rate these combinations. However, the full profile method is limited when more than eight or ten factors are involved. In this case respondents experience information overload and are likely to make their selection based only on a partial combination of factors. *Hybrid conjoint models* (Green, 1984) were developed to facilitate conjoint analysis with a large number of factors.

Hybrid conjoint models are so called since they combine a self-explicated compositional model followed by a de-compositional conjoint model. In the first stage respondents are asked to state – for each factor – the desirability of the various factor's levels to them, as well as the importance they assign to this factor. Multiplying the two indicators yields the value of each combination of factors and their levels. At the second stage respondents evaluate a small set of three to nine stimuli using full profile conjoint analysis to further refine the derived values. Hybrid conjoint models are not as powerful as the full profile method mainly because of the self-explicated component they entail. In a study by Green (1984) the full profile method proved to be better than the hybrid method in five out of the seven cases examined.

The decision of the data collection method for this study is complicated. The Delphi pilot study resulted in a list of 30 characteristics of knowledge and knowledge sources. This large number of characteristics requires the use of a hybrid conjoint model. However, as mentioned, these models perform worse than the full profile method. Thus, in order to maintain simplicity of the study and gain more powerful results, we have decided to limit the number of factors to ten and use the more popular full profile method. The top ten factors will be selected based on the rating of factors in the second round of the Delphi study. We will discuss this decision further in the last section outlining the challenges of the study.

Stimulus set construction. The number of stimuli used in the conjoint analysis is derived from the number of factors and levels within each factor. For example, in a study with three factors with two levels each the total number of stimuli is eight (2x2x2). A design that includes all possible combinations of factors and levels is called a *full factorial design.* As the number of factors and levels grows the number of stimuli in the full factorial design also grows and increases the burden on respondents. A *fractional factorial design* enables the use of an orthogonal subset of all possible stimuli. Most statistical software packages can create a fractional factorial design for conjoint studies.

Measurement scales for the dependent variable. The selection of stimuli by respondents can be carried out by ranking or rating. Ranking is more reliable but much more difficult to administer, especially with a large number of stimuli (Green et al, 1988). We will use a metric rating scale of respondents' intention to use the knowledge. A rule of thumb for the rating approach is to use an 11-point scale when the number of stimuli is less then 16 and a 21-point scale when the number of stimuli is larger (Hair et al, 1992).

Estimation method. Our selection of the metric rating method for the measurement of the dependent variable implies that we will use a least squares regression analysis as our estimation method. This type of method is common in many conjoint studies and was used in over 50% of conjoint analysis studies evaluated by Wittink and Cattin, (1989).

Table 3 summarizes the design choices made in this study.

Step	Selected design
1. Selection of preference model	Additive (main effects) model. Separate part worth estimations.
2. Data collection method	Full profile method with the top ten attributes from the Delphi study.
3. Stimulus set construction	Fractional factorial design.
4. Stimulus presentation	Text. Web-based.
5. Measurement scales for the dependent variable	Rating of intentions to use knowledge.
6. Estimation method	OLS regression analysis.

Table 3: Steps in designing a conjoint analysis

Reliability and Validity. Empirical evaluations of conjoint analysis studies provide evidence for high reliability and validity of the method in general (Gegax and Stanley, 1997, Green and Srinivasan, 1990). Specific tests to evaluate the reliability and validity of a conjoint study include test-retest reliability and holdout samples (Cattin an Wittink, 1982, Green et al, 1988). Test-retest reliability is conducted by including several repeated stimuli for each respondent. These stimuli are evaluated using a correlation coefficient or by using a special F test, known as the Chow test, to identify differences between the two replicated stimuli. Internal validity is evaluated using a holdout sample. This sample includes specific stimuli - drawn from the full range of stimuli - that are evaluated by respondents and compared to the prediction of the model developed in the analysis.

Hypothesis testing. Hypotheses H1 and H2 will be tested based on the significance of the regression coefficients of the factors representing source and knowledge characteristics. To see if there are differences in the evaluation of products between groups with specific characteristics (hypotheses H3-H5) we rely on the ability of the conjoint method to identify market segments within the set of responses. For example, conjoint analysis can find specific product attributes that are more important within one group of respondents than within other groups.

To create groups that may differ in their evaluations of the different factors we will again provide respondents with specific examples to refer to when selecting knowledge characteristics. The examples will provide different levels of equivocality and expertise. In addition, we will select respondents from different organizations and evaluate the organizations' knowledge intensity and level of formalization.

5. Summary

5.1 Challenges

In the evaluation of KMS our main challenge is including advanced knowledge generation systems such as data mining systems. These systems have unique characteristics that distinguish them from other types of KMS we have studied so far. However, we would like to develop some evaluation criteria for these systems in order to examine how well they support the generation of knowledge as well as individual learning.

The main challenge in the empirical study is the manipulation of equivocality, expertise and organizational characteristics. We hope that by providing users with specific examples we will be able to attain meaningful results. We have so far conducted the Delphi pilot studies and it seems that the manipulations of the example provides some differences in required characteristics.

An additional challenge concerns the design of the conjoint analysis and the selection of factors to use. We selected the full profile method mainly because of the weaknesses of hybrid conjoint models. However, we lose information concerning other relevant factors when using this method. An additional decision that we made concerns the factors that are chosen for the conjoint. The selection rule employed is to include the top ten factors identified in the Delphi study. We have considered another set of factors as well. Since this study aims to improve the design of KMS we have considered including only variables that are relevant for KMS. For example, the reliability or friendliness of a knowledge source may be important to respondents and included in the top ten attributes. However, these characteristics are irrelevant to the design of a KMS since they cannot be objectively measured and represented by the system. We consider conducting an additional conjoint analysis in the future to test only these 'objective' factors for the design of KMS.

5.2 Contribution

The study examines the shortfalls of KMS by deriving organizational KM requirements that are drawn from organizational theories and knowledge management processes. In addition, the study examines the meta-knowledge requirements of users in order to facilitate a more effective design of KMS.

There are two main contributions for this work. First, our evaluation of existing KMS indicates the problem areas that should be resolved in order for KMS to support more effective KM. In addition, we provide a framework to assist organizations in selecting and designing KMS that best fit their knowledge needs. For example, if a company wishes to focus on knowledge sharing it should select a product that is based on the network deign. If it wishes to improve the management of organizational knowledge, it should examine the available meta-knowledge of the proposed KMS.

The second main contribution is identifying the meta-knowledge required by potential users of a KMS. The proposed empirical research has both academic and practical contributions by improving our understanding of how users select knowledge. The dimensions of meta-knowledge can be applied in the design of knowledge management systems and enable more effective management of organizational memory. The use of meta-knowledge can also improve the support given by existing knowledge management systems to organizational memory.

References:

[1] ALAVI M. and LEIDNER D. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly,* 25(1).

[2] ALAVI M., (2000). Managing Organizational Knowledge. In *Framing the Domain of IT Management* (ZMUD R. Ed.).

[3] ARGYSIS, C. and D. SCHON (1978). *Organizational learning: A theory of action perspective*. Reading, Mass: Addison Wesley

[4] AUTIO, ERKKO, SAPIENZA, HARRY J., ALMEIDA, JAMES G., (2000), "Effects of age at entry, knowledge intensity, and imitability on international growth", *Academy of Management Journal*, Oct 2000.

[5] BEDARD, JEAN, CHI, MICHELENE T H, GRAHAM, LYNFORD E, SHANTEAU, JAMES, (1993), "Expertise in auditing; Discussion", *Auditing.*

[6] BROWN, J.S. and P. DUGUID (1991). Organizational learning and communities of practice: toward a unified view of working, learning, and innovation. *Organization Science* 2(1)

[7] BROWN, J.S. and P. DUGUID (1998). Organizing knowledge. *California Management Review,* Spring 1998

[8] CATTIN, P. and R. R. WITTINK (1982). "Commercial Use of Conjoint Analysis: A Survey," *Journal of Marketing*, 46(3).

[9] DAFT R. L., and MACINTOSH N. B., (1981). "A Tentative Exploration into the Amount and Equivocality of Information Processing in Organizational Work Units",*Administrative Science Quarterly,* 26(2)

[10] DAFT, R.L., and K.E. LENGEL, (1986). "Organizational Information Requirements, Media Richness and Structural Design", *Management Science* 32.

[11] DAVENPORT, T.H. and L. PRUSAK (2000). *Working Knowledge: How organizations manage what they know.* Harvard Business School Press.

[12] DAVENPORT, THOMAS H., SMITH, DAVID E., (2000). "Managing Knowledge in Professional Service Firms", in *The Knowledge Management Yearbook 2000-2001*, Cortada and Woods eds. (Butterworth-Heinemann).

[13] DELBECQ A.L., VAN de VEN, A.H.., and D.H. GUSTAFSON, (1975). *Group Techniques for Program Planning: a guide to nominal group and delphi processes,* (Scott, Foresman and Company)

[14] DENNIS ALAN R., and KINNEY SUSAN T., (1998). "Testing media richness theory in the new media: The effects of cues, feedback, and task equivocality", *Information Systems Research,* 9(3)

[15] DUFFY JAN (2000). "The KM technology infrastructure", *Information Management Journal*, 34(2)

[16] FERRELL, O.C., and SJ. SKINNER, (1988). "Ethical Behavior and Bureaucratic Structure in Marketing Research Organizations" *Journal of Marketing Research* 25 (February).

[17] GARTNER GROUP (2002). The 2002 Knowledge Management Hype Cycle. F. Caldwell, K. Harris, *InSide Gartner, January 2002, IGG-01232002-01*

[18] GEGAX D. and L.R. STANLEY, (1997). "Validating Conjoint Hedonic Preference Measures: Evidence From Valuing Reductions in Risk," *Quarterly Journal of Business and Economics*, (Spring), 31-54.

[19] GORDON M.E. and K.D. LIMA-TURNER, (1997). "Consumer attitudes towards Internet advertising A social contract perspective". *International Marketing Review,* 14 (5)

[20] GREEN P., TULL D.S., and ALBAUM G., (1988). *Research for Marketing Decisions.* Prentice-Hall

[21] GREEN P.E., KRIEGER A.M, and WIND Y., (2001). "Thirty Years of Conjoint Analysis: Reflections and Prospects". *Interfaces* 31(3)

[22] GREEN, P. E. (1984). "Hybrid Models for Conjoint Analysis: An Expository Review," *Journal of Marketing Research*, 19.

[23] GREEN, P. E. and V. R. RAO (1971). "Conjoint Measurement for Quantifying Judgmental Data," *Journal of Marketing Research,* 8.

[24] GREEN, P. E. and V. SRINIVASAN (1990). "Conjoint Analysis in Marketing: New Developments With Implications for Research and Practice," *Journal of Marketing*, 54(4).

[25] GRUBER T. (1993). Toward Principles for the Design of Ontologies Used for Knowledge Sharing, *Technical Report KSL 93-04*, Knowledge Systems Laboratory, Stanford University.

[26] HAIR J.F., ANDERSON R.E., TATHAM R.L., and BLACK W.C, (1992). *Multivariate Data Analysis.* 3rd ed., Macmillan Publishing Company, NY.

[27] HOVLAND, CARL I., JANIS, IRVING L., KELLY, HAROLD H., (1953). *Communication and Persuasion; psychological studies of opinion change* (New Haven, Yale University Press).

[28] KALFOGLOU Y., MENZIES T., ALTHOFF K. D., MOTTA E., (2000). "Meta-knowledge in systems design: Panacea ... or undelivered promise?", *Knowledge Engineering Review,* 15(4)

[29] KPMG (1998). The Knowledge Management Research Report 1998.

[30] KPMG (2000). The Knowledge Management Research Report 2000.

[31] LEHRER K. (1990). *Theory of Knowledge.* Westview Press, San Francisco.

[32] LIANG RULKE, D. and D. RAU, (2000). "Investigating the Encoding Process of Transactive Memory Development in Group Training", *Group & Organization Management,* 25(373-396)

[33] LIM KAI, and BENVASAT IZAK (2000). "The effect of multimedia on perceived equivocality and perceived usefulness of information systems". *MIS Quarterly* 24(3).

[34] LIVINGSTON, (1997), Metacognition: An Overview, www.gse.buffalo.edu/fas/shuell/cep564/Metacog.htm

[35] MORELAND R.L, ARGOTE L., and R. KRISHNAN, (1996). "Socially Shared Cognition at Work: Transactive Memory and Group Performance", in Nye and Brower eds. *What's Social About Social Cognition?"*, (57-86), SAGE publications.

[36] NELSON, KAY, NADKARNI, SUCHETA, NARAYANAN, V. K., GHODS, MEHDI, (2000). "Understanding Software Operations Support Expertise: A Revealed Causal Mapping Approach", *MIS Quarterly* 24(3)

[37] NONAKA I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, 5(1).

[38] O'LEARY D. (1999). Using AI in Knowledge Management: Knowledge Bases and Ontologies. In *The Knowledge Management Yearbook 1999-2000* (Cortada and Woods eds.). Butterworth-Heinemann.

[39] PLANT ROBERT, and GAMBLE ROSE, (1997). "Using meta-knowledge within a multilevel framework for KBS development", *International Journal of Human-Computer Studies*, 46 (523-547)

[40] PUGH, D.S., HICKSON, D.J., HININGS, C.R., AND TURNER, C., (1968). "Dimensions of Organization Structure", *Administrative Science Quarterly* 13.

[41] RUGGLES R. (1997). Knowledge Tools: Using Technology to Manage Knowledge Better. working paper, http://www.cbi.cgey.com/pub/docs/KnowledgeTools.PDF

[42] SCHMIDT ROY, LYYTINEN KALLE, KEIL MARK, CULE PAUL, (2001). "Identifying software project risks: An international Delphi Study", *Journal of Management Information Systems*, 17(4).

[43] SCHMIDT, ROY C., (1997). "Managing Delphi surveys using nonparametric statistical techniques", *Decision Sciences*, 28(3).

[44] SCHWARTZ D., (1999). "When email meets organizational memories: addressing threats to communication in a learning organization", *International Journal of Human-Computer Studies,* 51.

[45] SOO J.T., (1999). "Strategies for reducing consumers' risk aversion in Internet shopping" The *Journal of Consumer Marketing*, 16(2)

[46] STEIN E., 1995, Organizational memory: Review of concepts and recommendations for management, *International Journal of Information Management*, 15(1)

[47] VAVRA T., GREEN P.E., and KRIEGER A.M, (1999). "Evaluating EZ-Pass". *Marketing Research* 11(3)

[48] WALSH J. and C. UNGSON (1991). Organizational Memory. *The Academy of Management Review* 16(1)

[49] WEGNER D. M., (1987). "Transactive memory: A contemporary analysis of the group mind." In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior* (pp. 185-208). New York: Springer-Verlag.

[50] WEGNER D. M., (1995). "A computer network model of human transactive memory", *Social Cognition*, 13(3).

[51] WIND, J., P. E. GREEN, D. SHIFFLET, and M. SCARBROUGH (1989). "Courtyard by Marriott: Designing a Hotel Facility with Consumer-Based Marketing Models," *Interfaces*, 19(1).

[52] WITTINK, D. R. and P. CATTIN (1989). "Commercial Use of Conjoint Analysis: An Update," *Journal of Marketing*, 53.

Appendix A: List of tools reviewed

General KMS

Verity K2 Enterprise
Hyperwave eKnowledge Portal
Ptech Enterprise FrameWork
Lotus Discovery
Quantum

Content Management

Smartlogik Insight™
RetrievalWare
Netegrity Interaction Server
SERbrainware™
DecisionStream
Enfish Enterprise
Metadata Creator
MetaTagger
80-20-DME 6.9 SPI
Autonomy IDOL

Knowledge search and retrieval

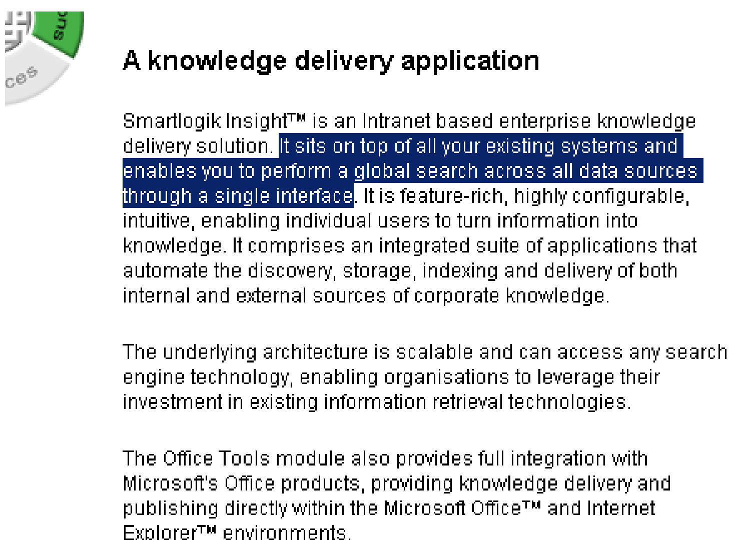
Semio map
ClearResearch
Organik
Divine Athena
Domain Knowledge
LexiQuest Guide
80-20 Retriever
Muscat Discovery™
SearchServer
BASIS
eGain Knowledge Gateway
Viador E-Portal Framework

Knowledge Sharing

Divine OpinionWare
AskMe Enterprise
KnowledgeLEAD
Infinos
ERoom
Quiq Connect
IntraKnexa
Knowledge Mail
Plumtree Collaboration Server
Enterprise Expertise Management
Notes R5
Eridu - web based groupware
ICQ Groupware

Appendix B: An example of deriving KM functionalities

Below is a screen shot from the website of one of the content management tools. The highlighted section implies that the tool supports the retrieval of knowledge from memory and therefore activity ST2. The analysis of tools was made by identifying as many sentences as this one on the company's website and classifying them according to the functionalities identified in this paper.



A knowledge delivery application

Smartlogik Insight™ is an Intranet based enterprise knowledge delivery solution. It sits on top of all your existing systems and enables you to perform a global search across all data sources through a single interface. It is feature-rich, highly configurable, intuitive, enabling individual users to turn information into knowledge. It comprises an integrated suite of applications that automate the discovery, storage, indexing and delivery of both internal and external sources of corporate knowledge.

The underlying architecture is scalable and can access any search engine technology, enabling organisations to leverage their investment in existing information retrieval technologies.

The Office Tools module also provides full integration with Microsoft's Office products, providing knowledge delivery and publishing directly within the Microsoft Office™ and Internet Explorer™ environments.

Progress Report:

Developing Effective Knowledge Management Systems

The stages below describe the progress made so far and outline of future work.

Literature Review - completed

Development of research questions and research model – completed

Empirical study 1: Evaluation of KMS

	Expected completion
Development of theoretical framework	Completed
Initial evaluation of KMS	Completed
Extension of the work to include knowledge generation tools, and tools evaluation	October, 2002

Empirical study 2: Identifying meta-knowledge

Part A: Delphi study

	Expected completion
Study design and development of questionnaires and website	Completed
Pilot studies	June, 2002
Delphi study	August, 2002
Analysis of results	September, 2002

Part B: Conjoint analysis

	Expected completion
Study design and development of website	November, 2002
Contacting participants	January, 2002
Pilot study	February, 2002
Conjoint analysis study	May, 2003
Analysis of results	June, 2003

Writing dissertation – expected completion date, July – August, 2003