Communications of the Association for Information Systems

Volume 17 Article 24

April 2006

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VALIDATION OF A CONTENT ANALYSIS SYSTEM USING AN ITERATIVE PROTOTYPING APPROACH TO ACTION RESEARCH

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ABSTRACT

In the face of a more rapid pace of scientific development, academic societies and competitive organizations alike are seeking new methods for content analysis. This paper describes a theoretically driven action research study that delivers a technology-mediated solution for specifying, organizing, representing and using elements of meaning in a body of knowledge. The theoretical basis, 'ontological specification' is of particular interest to IS professionals, particularly those involved in analysis and design, because it guides the efficient transformation of tacit knowledge into an explicit form. The technology-mediated solution influenced by ontological specification was validated through an iterative prototyping form of action research. Users reported that the system was useful in their work, easy to use, and compatible with collaborative work when using it for content analysis in academic research.

Key Words: Action Research, Knowledge Management, Content Analysis, Ontological Specification, Ontology, Tacit Knowledge, Explicit Knowledge, Organizational Learning, Knowledge Acquisition, Information Distribution, Information Interpretation, Organizational Memory

I. INTRODUCTION

Since the proliferation of information technology, organizations have been faced with the problem of competing in increasingly complex and information-intense environments. In particular, the annual doubling of information available on the Internet [Turban, McLean and Wetherbe, 1999], in traditional press, and more frequent and intense interactions with competitive environments introduces unprecedented learning opportunities for modern organizations. Similarly, modern academic societies are faced with similar information handling challenges. Exhibiting an unprecedented capacity for scientific progress, modern academic societies are producing record numbers of scholarly books and research [Huppes, 1987; Price, 1963]. For interests in academia and practice, the pressure to effectively consume, retain, and manage knowledge is vital in the ongoing pursuit of outpacing obsolescence. This need coincides with limited means for technologically supporting the capture, interpretation, prioritization, and presentation of important knowledge.

In organizational practice, managers have responded to the increased masses of strategically critical contextual and conceptual information by developing new information technologies (i.e., decision support systems, expert systems, artificial neural networks, simulation, etc.) for improving organizational consumption of knowledge. Cutting-edge companies like LearnerFirst Corporation offer information systems and methods designed to "rapidly convert top-performer expertise into knowledge assets that enhance corporate valuation and protect the organization from knowledge degradation" [LearnerFirst, 2004]. This perspective involves the redesigning of focused knowledge domains so the new representations are structured in such a way that organizational members can more readily understand the information. The purpose of such tools is to empower organizations and their members in a way that will improve adaptability in the face of dynamic environments. Such systems are said to support knowledge management (KM), and have been developed conceptually as *knowledge management systems* [Alavi and Leidner, 2001].

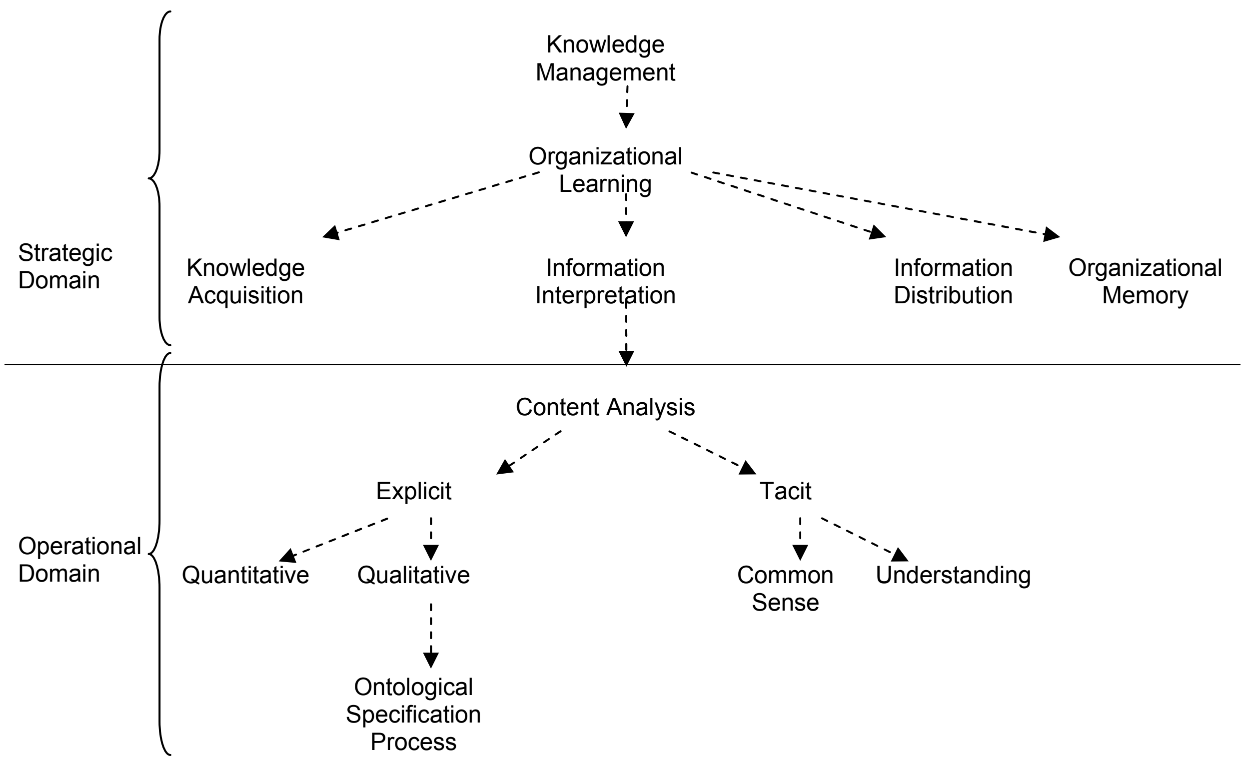

Figure 1. A Content Domain for Knowledge Management

Figure 1 provides a content framework that indicates the relationships between knowledge management, organizational learning, content analysis, and our proposed *ontological specification process (OSP)*. For the purposes of this study, OSP is a general concept involving the development and use of ontologies. Figure 1 indicates the conceptual placement of OSP as it relates to the overall topic of KM. The figure shows that an important action-oriented perspective on KM is organizational learning, which Huber (1991) delineates into four categories of collective information processing: acquisition, interpretation, distribution, and memory. We view content analysis, defined as “the systematic, objective, quantitative analysis of message characteristics” [Neuendorf, 2002, p. 1], as a subcategory of interpretation. The figure also indicates that content analysis may be applied to problem domains using both tacit (primarily via the observations of interactions) and explicit (observed and encoded data) information. OSP focuses on explicitly held qualitative data and is therefore applicable in the development of academic manuscripts. In short, it intends to support the vast number of KM problem domains (including academic and practitioner) involving written text in any media.

There are two goals of this research. First, we wish to test OSP as a useful means for managing knowledge while conducting academic research. This paper reports on an action research study on the specific procedures of the OSP methodology employed by the researchers and subjects. We present four explicit OSP steps members can perform to enhance organizational learning: *selection*, *delineation and denotation*, *transfer*, and *use* of concepts. The second goal of this research is to iteratively define, create, and test a new class of information system based on OSP principles. Thus, a prototype information system, informed by theory on ontological development, is the deliverable of this research. This is accomplished through an iterative prototyping approach to action research which infuses OSP theory with practical needs. OSP is the concept we are trying to test by using an iteratively developed prototype as a research instrument. We used the process of constructing a Microsoft Excel-based prototype to collect data and integrate theory into practice (an assumption of the paper is that the reader has basic understanding of Excel-based systems and concepts).

We named the Excel-based prototype iteratively defined and constructed in this study the ontological support system (OSS), named for the theoretical concept (OSP) it supports. The OSS is an important product of this research and the focus of a companion CAIS article illustrating its use (Templeton and Lee, 2006). Figure 2 illustrates the relationship between OSP, the validation process, Excel software, OSS and ontologies. The validation process integrates action research, prototyping, and structured interview concepts. Action research approaches were used in the identification of general problems and potential solutions based on the problem domain (academic research). Evolutionary prototyping was used to refine the Excel-based OSS by allowing user involvement during its development. The contents of the OSS were developed along with program aspects (e.g., data validation and the use of named lists). The OSS interface provided a repository that supported user learning about 1) the OSS and 2) the content domain. Thus, the OSS allows for the representation, deliberation, and modification of system and knowledge structures in a collaborative or single-use environment. While the OSS was the deliverable of this research, ontologies are the deliverable of both OSP (manual) and OSS (computer-mediated).

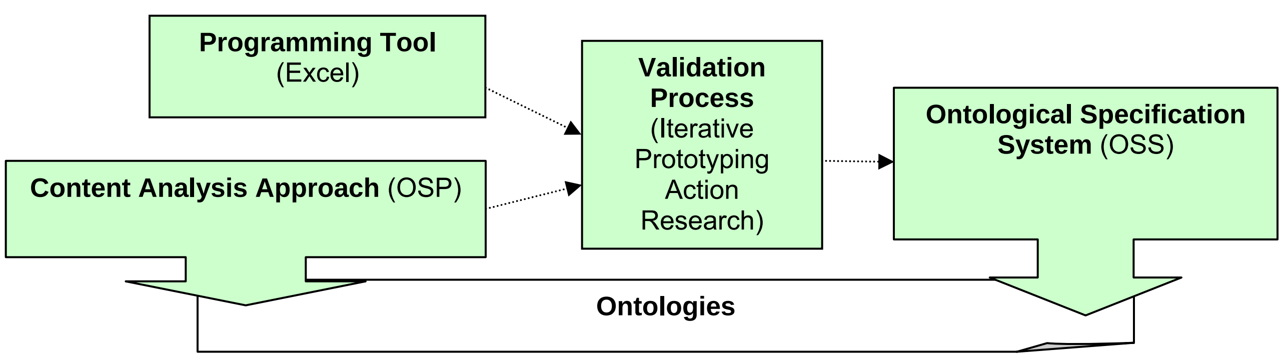

Figure 2. Relationship between Research Actions, Tools, and Outcomes

There are significant implications of this prototype for MIS researchers and practitioners, as it may be used to generate ontological representations of a wide variety of MIS topic domains [Alavi and Leidner, 2001]. The ontology promises an explicit, comprehensive and organized set of vocabulary terms and logical statements as opposed to tacitly held knowledge, which is very difficult to manage.

This paper is organized as follows: a description of the action research methodology, validation of findings, and conclusions. First, we begin with a description of the theoretical background that includes several Figure 1 components.

II. BACKGROUND

In order to better handle and present knowledge, researchers have tried improving techniques for the content analysis of both qualitative and quantitative data. Much work has been done with the goal of providing algorithmic approaches for automating the extraction of knowledge from empirical data. Both qualitative and quantitative modes of content analysis have received considerable attention in methodology research, as is illuminated in the remainder of this section.

CONTENT ANALYSIS OF EXPLICIT KNOWLEDGE

Researchers in information systems, computer science, and particularly in artificial intelligence (AI) have made several attempts to formalize the content analysis of explicit knowledge. Perhaps a primary motivator is the vast potential for improving a wide range of social interests – focusing on the content analysis of explicit knowledge promises to improve upon human and organizational learning [Argyris and Schon, 1978]. In support of organizational and human learning, this paper provides some insights on employing OSP by depicting the application of one such method in the area of KM.

The applicability of KM-supportive systems is that it allows methods that automate or support human information processing tasks to be constructed from a vast myriad of sources. The goal of such methods is the reduction in need for humans to be inundated with the belaboring task of extracting meaning from volumes of text. Although the field of KM remains in its infancy, the prospect of gathering all of the information published in any content area is formidable and often unrealistic. This is especially true given the enormous growth in the amount of information published each month on the Internet and in the academic and trade press. The immature, yet dynamic, nature of development associated with some fields (e.g., KM, environmental relevance, organizational learning) has resulted in little structure of content in terms of frameworks, commonly held beliefs, taxonomies, and terminology. This has made many new fields excellent targets for the application of OSP, a method that will explicitly provide for structuring.

Content Analysis of Quantitative Explicit Knowledge

The motivation for researching quantitative data interpretation derives primarily from the need for organizational managers to be relieved of information overload in order to improve decision-making effectiveness. Researchers also use quantitative methods to facilitate incremental organizational change (i.e., total quality management). Past work in the structuring of numeric data for organizational benefit is well represented in many fields. The entire field of statistics (simple statistics, factor analysis, regression analysis, ANOVA, etc.) is dedicated to quantitative data interpretation. Many disciplines (e.g., management science, operations research, and decision science) all include a vast range of well articulated techniques for generating new inferences from raw quantitative data.

Content Analysis of Qualitative Explicit Knowledge

The long tradition of research in qualitative data interpretation has been aimed at helping organizations handle data and knowledge for the facilitation of effective change. Such information processing includes data warehousing, radical change (i.e., business process reengineering), technology adoption, strategy implementation, systems analysis and design and others. Methods dedicated to structuring qualitative text data also have a long tradition, beginning with the study of language structures (parts of speech, grammar, etc.). More recently, proprietary text processing methods have been made possible from the use of computer-based information technology.

Many proprietary IT-enabled methods exist in practice, particularly as a part of the code logic in organizational systems. For instance, a rudimentary method might include the counting of each different word appearing in a body of text. The development of such a simplistic database enables the objective development of a common argot by using the most commonly used terms found in the analysis. The argot can then be used subjectively to decide which themes (i.e., technological or managerial terms) are emphasized and what themes are important in a body of text. For example, a researcher can determine if a CEO is more concerned with technical or managerial issues by analyzing which type of words he/she emphasizes in the annual statement. In this way, such a method can serve as a utility function used in the preliminary analysis of a body of text.

Motivation for the organizational development of proprietary methods for content analysis derives from the need for the automation of work in technology (software in particular) development. Computer automated software engineering (CASE) tools have long been the focus of such efforts, now seeking to allow systems analysts to enter prose-formatted text into a CASE tool designed to convert the highly human-logical, yet ill-structured data into programming code.

A classic methodological example of analyzing language structures for organizational change has evolved in the form of IBM's *ISA Framework* [Sowa and Zachman, 1992; Zachman, 1987]. The ISA Framework uses six possible questions that may be asked about a complex system. Each category represents six knowledge areas, each corresponding with a role for system analysts. The framework considered every system to be composed of data ("what"), process ("how"), networks ("where"), people (“who”), time (“when”), and motivation (“why”). These systems properties represented all questions available in the English language and when answered, form ‘artifacts.’ When these artifacts are aggregated, they form a comprehensive model of the ‘real’ system. Furthermore, implications were that the information could be represented in computer-based modeling tools (i.e., CASE) that enabled rapid and efficient sharing and dissemination of the representations.

THE NEED FOR THE DEVELOPMENT OF CONTENT ANALYSIS METHODS

There already exist various forms in which AI applications work to transform English statements into computer-based representations for easier machine processing. These methods generally take the form of transferring statements into objects, actions and actor representations for the output of logical inferences [Schank, 1984]. While serving its purpose in uncovering inferences, this method does not have practical use in processing a mass of explicit text.

A convenient notion in information systems literature concerns the applicability of representing themes of meaning in relational form. Specifically, the process of *database normalization* relates strongly to judgments made concerning the appropriateness of ontology structure during OSP. In fact, the two processes are very similar. Both are attempts at capturing meaning using standardized representations of meaning (concepts and subconcepts for ontological specification and relations and elements for normalization). It can be said that both processes are attempts at organizing knowledge in a more straightforward manner for an end user (or agent) of the knowledge acquired. However, data normalization requires that data first be place in relational form. We show here that OSP can be used as a technique for harnessing immensely vast and fractious textual data into the relational form.

III. METHODOLOGY

Action research is an interventionist approach which is described as "a post-positivist social scientific research method, ideally suited to the study of technology in its human context" [Baskerville and Wood-Harper 1996, p. 235]. The approach is heavily cross-disciplinary and used "to test a working hypothesis about the phenomenon of interest by implementing and assessing change in a real-world setting" [Lindgren et al. 2004, P. 441]. Action research involves the development and testing of solutions during close collaborations between researchers and practitioners in the real-world setting. Action research approaches are used in the information systems field primarily to understand systems development methodological issues.

Among the ten types of action research in information systems defined by Baskerville and Wood-Harper (1998), the study is classified as iterative-prototyping. Iterative action research involves a repeating sequence of steps as a primary organizing principle to solve the problem. Prototyping incorporates action research qualities and goals in the prototyping of an information system that aims to impact the organization. In the current research, the method involved the iterative design, construction, and implementation of organizational learning behaviors into the structure and culture of the department.

The research approach is validated by four essential criteria developed by Susman and Evered [1978] that have been used in prior action research in MIS [Baskerville and Stage, 1996]. Each of the criteria was met during the study and supports the validity of the findings. Table 1 shows four essential action research criteria and this study's characteristics.

Table 1. Action Research Criteria and Associated Study Characteristics

No.	Criterion	Study Characteristics
1	The researcher intervened by moving the design of the potential solution into the subject organization	A faculty member and doctoral student formed the action research-design team. Doctoral students, active in academic research, served as users-subject.
2	The project is collaborative between researcher and practitioner(s)	Subjects both used and influenced (through feedback to the research team) the design of the OSP. One of the doctoral students served as both researcher-designer and user-subject.
3	The research goal is to understand rather than interpret the proposed approach	Understanding was promoted by including practicing researchers in both the design and use teams in a joint, iterative prototyping approach
4	The project yields a solution to an immediate problem.	Many scientific manuscript writing problem categories (note recording, editing, organizing, etc.) were addressed during the study, and the OSP provided a relative advantage over traditional methods.

IV. THEORETICAL FOUNDATIONS

Primarily due to their hierarchical properties, ontologies have become an important part of a wide range of MIS research areas. Ontologies are the outcomes of complex socio-technical processes that are often the consequences of iterative refinement through sociological acceptance and psychology-driven choices. This is an attempt to make OSP technology-mediated in an easily accessible computing environment.

Consistent with good practices in action research [Baskerville and Myers, 2004], the delivered prototype of this research was heavily influenced by theory. The following section describes the theoretical foundations of ontological specification processing so that the contributions to MIS research will be better understood.

ONTOLOGICAL SPECIFICATION PROCESSING

An ontology represents a specified (via researcher interpretation) hierarchical scheme of concepts and relationships that holistically describes a topic of interest. For our purposes, it can yield declarative knowledge about the structure and processes related to the KM concept. It can serve as a formal vocabulary for researchers, instructors, students, and practitioners in the KM community of practice and includes logical descriptions of the items, relationships between items, and how items cannot be related [Gruber, 2006]. The utility of specific terminology is a greater stimulation in more refined concepts in the field, which can result in further formalization of the topic area and structuring of decision-making processes in the field. Further, the KM ontology can uncover relationships between resident subconcepts when such relationships are of interest.

The use and depiction of ontologies in IS research is rapidly gaining prominence [a review and directions for future research on ontologies in IS research is provided in Kishore, Sharman, and Ramesh (2004)]. In IS epistemology, ontologies play the role of concretely defining reality in the positivist worldview [Weber, 2004], as they promise to positively affect both research and system qualities. To briefly define the place of ontologies in the IS discipline, we segment its interest areas into two broad areas: 1) during IS development and use (i.e., along the SDLC) and 2) its physical use in systems.

The ontology is becoming an increasingly important theoretical element of IS development [Livari, Hirschheim, and Klein, 1998]. In general, ontologies are used to explicitly represent a structured summary of a knowledge domain. Three distinct and illuminative uses of ontologies in systems development have included 1) the formal specification of information during requirements determination [Sharman, Kishore, and Ramesh, 2004], 2) conceptual modeling during analysis [Wand and Weber, 2002], and 3) the organization of system evaluation information during testing [Guarino and Welty, 2002; Shanks, Tansley, Weber, 2003]. In the use of systems, ontologies purport to influence extent of use and user efficacy [Edgington, Choi, Henson, Raghu and Vinze, 2004], two important user concerns.

The hierarchical properties of ontologies make the concept heavily applicable to systems-related concepts. For one, ontologies have made significant theoretical and practical inroads in the area of database. Researchers have studied ontologies as important elements of data management [Everett, Bobrow, Stolle, Crouch, Paiva, Condoravdi, van den Berg, Polanyi, 2002] and access [Hovy, 2003]. In formal and large IS design projects, ontologies are principle design elements in XML-based applications [Smith and Poulter, 1999]. Another way of embedding ontologies in systems is in the model component of decision support systems [Fierbinteanu, 1999].

For both SDLC and systems-embedded categories, the proper design of ontologies [Devedzic, 2002; Gruninger and Lee, 2002; Holsapple and Joshi, 2002; Kishore, Zhang, and Ramesh, 2004] has become a new and potentially fruitful area of IS research. The process of creating ontologies results in greater clarity and formalization regarding the contents of a knowledge domain. This process of greater formalization inevitably results in prescriptive associations in academic fields, which means that methods can be prescribed for various contingencies found in practice. Ontologies can be viewed as a knowledge-based communications technology in that a greater ability to represent and communicate knowledge about a concept is possible as more terms and relationships are uncovered in the OSP. With this definition of ontological specification at hand, we can see that the process itself can serve as a subconcept in the KM ontology, a scenario that adds to the implications of this research.

In viewing the OSP as a knowledge-based technology, researchers at Stanford University are at the forefront. There, a web-based ontology building application resides, allowing independent and remote users to build ontologies of any subject matter. The system, called *Ontolingua*, serves as a knowledge acquisition laboratory for the AI faculty and supports the standardization of knowledge structures transferable to intelligent software modules. The system has been used to build ontologies mainly in the field of AI, but some in areas which can be directly linked to KM: Bibliographic-Data, Documents, Job-Assignment-Task, User, Design, and Domain.

The many-to-many relationship in the ability of the application to receive ontology-building requests and to be able to transfer to varying software environments means that the OSP has received ontological attention. The ontology engineering perspective has yielded a meta-ontology that can be used across any knowledge domain.

AN ONTOLOGICAL SPECIFICATION PROCESS ILLUSTRATED

This section is provided to illustrate the phases and outcomes (primarily, the ontology) of OSP. This example illustrates the application of OSP to the content domain of KM. Ontological specification methodologies vary widely, but all conform to a common set of steps. These steps are 1) *selection* of the topic area, 2) *delineation* of concepts, 3) *denotation* of concepts in the known body of knowledge, 4) *transfer* to a usable medium, and 5) *use* of ontology stored in relational form. Table 2 shows that each OSP step corresponds with a distinct phase of organizational learning postulated by Huber [1991].

Table 2. OSP as an Organizational Learning Methodology

Organizational Learning	OSP Procedure	Purpose
Knowledge Acquisition	*Selection* of subtopic	To acquire all relevant literature needed for analysis
Information Interpretation	*Delineation* and *Denotation* of concepts	To establish patterns in all available knowledge
Information Distribution	*Transfer* to usable medium	To communicate to organizational structures for use by org. members
Organizational Memory	*Use* of stored data in further research	To modify knowledge based on organizational experience

Topic Selection

Selection of the topic of KM for ontological analysis was done due to its place on the research continuum. A review of the literature showed that an overwhelming amount of the knowledge available about KM was descriptive in nature. This meant that most effort had been justifiably aimed toward the definition and uncovering of key concepts in the field. Very little academic empirical work had been conducted that uses examples of KM utilization in practice, except for conceptual (normative) works [Sanchez and Mahoney, 1996]. Thus, the field was a prime target for formal structuring methods such as ontological and taxonomic specification.

Delineation of Concepts

Operation of ontological specification should be seen as an iterative and subjective behavior of the agent operator and heavily dependent on operator learning. The classic iterative control process is used throughout ontology development, following the steps of 1) setting an ideal, 2) setting standards, 3) evaluation of feedback data, 4) changing operations or the ideal in perpetual cycles [Templeton and Snyder, 1999]. Deciding on an exact ontology cannot be accomplished in such a new and volatile field as KM, where expected discoveries in the field will relate to a redefinition of the ontology. Defining and placing relevant subconcepts in ontological form is done based on some purpose, such as 1) to define and refine a researcher's interests, 2) to capture common themes in a body of literature and 3) to organize experiential knowledge about a research topic.

Thus, the delineation of the KM concept does not mean that KM will be the most significant or important field in the analysis. It means that as we decompose the concept, other related concepts should be included in the study of KM (Table 3). For example, executive information systems, telecommunications and database are more prevalent in the eyes of managers, but can strongly support the organizational KM effort. The *relationship* between these important concepts and KM is of pertinent concern to users of the ontology and thus justifies its existence in the scheme.

An initial review of the KM literature revealed three categories of knowledge in the literature associated with the KM concept. These categories are Resource Meta-Data, KM Description and KM Operation (see Table 3). *Meta-Knowledge* involves the entomological view, which includes knowledge about sources, states, structures, processes, histories, and evaluations of knowledge about KM, including the current paper. In most fields, Meta-Knowledge is important for researchers, but of little value to practitioners. However, the understanding of Meta-Knowledge is the goal of one who studies KM. This category of knowledge is where the objectives of practice and academia coincide.

Table 3. A KM Ontology

- I. Resource Meta-Data
  - A. Source type (SO)*
  - B. Study Type (ST)
  - C. Academic base (AB)
  - D. Empirical Support (EM)
- II. KM Description
  - A. History of KM (HIS)
  - B. Definition of KM (DEF)
  - C. KM characteristics (CH)
  - D. How to determine the presence of KM (PRES)
  - E. Examples of KM and its Absence (EX)
  - F. KM Architecture (ARCH)
- III. KM Operation
  - A. Processes of KM (ACT)
    - 1. Determining info requirements during KM (IR)
    - 2. Knowledge Acquisition (KA)
    - 3. Data Management in KM (DM)
    - 4. Processing/Transforming Knowledge (PROC) Ontological Specification
    - 5. KM and GST (General Systems Theory)
    - 6. Organizational Learning (OL)
    - 7. Organizational Memory (OM)
  - B. Why KM is needed (NEED)
    - Control Theory and KM (CT)
  - C. Knowledge as Intangible Asset (IA)
    - 1. Knowledge capital theories (KT)
    - 2. Knowledge creation (KC)
    - 3. Intellectual Capital Management (ICM)
  - D. How KM impacts the organization (OI)
    - 1. Organizational change as related to KM (CH)
      - a. How technology can support KM (TECH)
        - i. Learning Systems (LS)
        - ii. Best Practices Databases (BEST)
        - iii. Organizational Memory Info. Sys. (OMIS)
        - iv. Networking and KM (NET)
      - b. KM culture (CULT)
    - 2. Organizational performance (OP)
  - E. Organizational use of KM (OUSE)
  - F. Benefits of KM (BEN)
  - G. Factors effecting quality KM effort (FEQ)
    - 1. Implementation of KM (IM)
    - 2. Evaluation of KM (EV)
    - 3. Characteristics of the Knowledge Manager or Group (CHAR)

* parentheses indicate subconcept tag used in text denotation process

The *KM Description* concept involves descriptive knowledge about the field. This type of knowledge is emphasized early in the development of academic fields and is concerned with the defining of key issues, terms, and the history of the field. Writers of KM literature have emphasized *KM Description* knowledge for better understanding of the meanings of the concept and related terminology. KM Operation involves the structure and processes associated with the topic. We use this type of knowledge to depict for management the way KM should be aligned and operate. This type of knowledge has been relatively rare in KM literature because the field has concentrated on describing the field (as in KM Description). Work in the area of operationalizing KM will lead to prescriptive knowledge about what causes, effects, and contexts are important in operating the organizational KM effort. Thus, this type of knowledge is the goal of academic research and study about the field, and is the direction KM is currently heading.

It is important to understand the three categories of KM knowledge posed in the framework. The nature of Meta-Knowledge is descriptive, as in the KM Description category. However, the former is used in describing KM knowledge, while the latter is used to describe KM. The KM Operation category is where we learn to competently manage knowledge and its processes.

Table 3 also shows how KM can be delineated into more specific subconcepts. For example, the early development stage of the field results in the need for researchers and practitioners to have agreed-upon definitions and a foundation for terminology. Hence, the consideration of the Definition of KM idea has become important and was placed as a direct subconcept of the KM Description concept in the ontology. The concept was derived by the consistent efforts by several 'guru's' offering varying definitions in the KM literature.

The ontology in Table 3 also shows the decomposition of the KM Operation subconcept of KM. KM Operation literature was described by seven subconcepts relating to the issues associated with KM practice. One intriguing facet of KM Operation is the Processes of KM subconcept, relating to the activities associated with KM practice. These activities may be classified as operational or managerial activities, but were explicitly mentioned in the literature as one of the seven categorizations shown. Further decomposition leads to the Processing/Transforming Knowledge subconcept, which includes practices such as Ontological Specification and the textual processing methods mentioned previously. This ontology shows the congruence in purpose between academics and practitioners in the KM field.

The previous description of the method of concept delineation highlights several problematic issues in the derivation and selection of subconcepts. First, the description points out that a methodology operator must subjectively select from competing ideas the most appropriate and pertinent subconcepts to be placed in the ontological structure. An important principle is that the operator must have knowledge in the area of interest due to the potential for researcher bias in selection. In his engineering approach to ontological specification, Gruber [1992] refers to this problem as encoding bias and uses it as a measure of ontology quality.

Denotation of Concepts

For immediate communication to a literature reviewer about what concept meaning is associated with a given set of text, the OSP operator simply denotes physically in the literature using concept-associated tags [Amidon and Skyme, 1996] such as those shown in parentheses in Figure 3. The use of the term 'tags' here intentionally refers to the potential for creating HTML language tags (e.g., "<descriptivetag></descriptivetag>") that categorize Internet-resident text based on meaning.

Implications for this are enormous for organizations wishing to perform focused web-based research, the findings of which can be expedited by such notations. The authors envision the extension of HTML language to include knowledge-

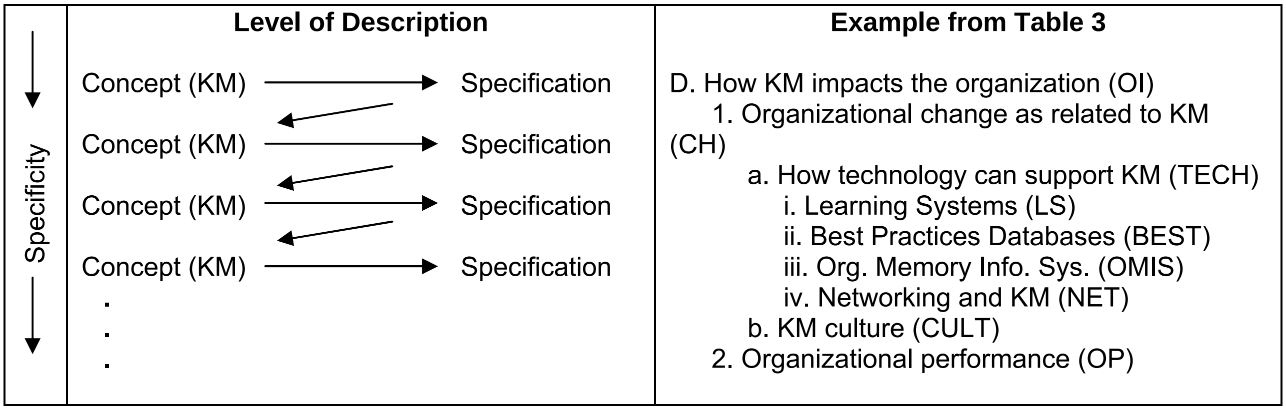

Figure 3. Delineation of Levels in the OSP

based tags that are visible to online search engines, but invisible to users. Notation tag creation is done with two purposes in mind: 1) to support the learning curve parameters of the denoting specialist and 2) to communicate to a user about meanings in the text. Denoting text can become extremely tedious without the utilization of communicative tags. For instance, the current methodology was initially employed using numeral tags until a more descriptive variable name approach evolved.

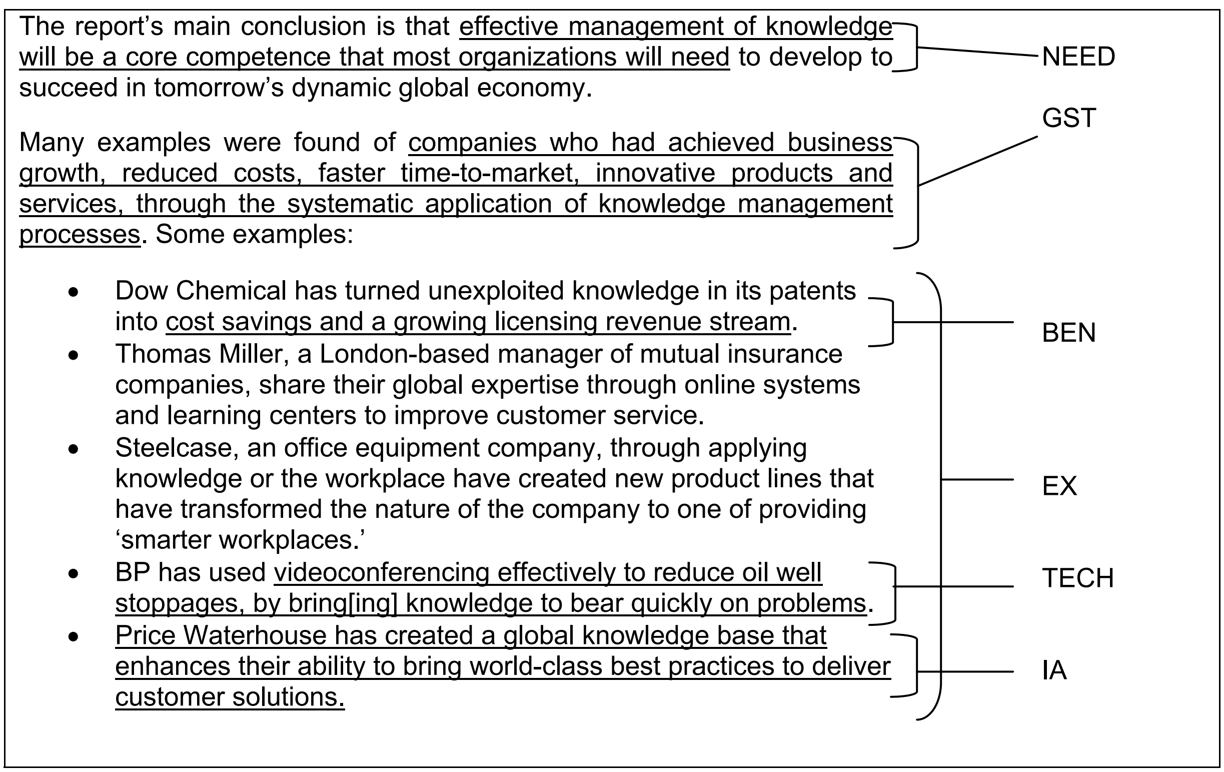

Figure 4. Examples of Denotation Applied to KM Literature

Denotation criteria, the standard by which each reviewed text set is evaluated, is an important consideration and should be documented for all denoting specialists employed on a specification project. Well-communicated and implemented evaluation criteria can result in less risk of subjective bias and other problems in the ontology. For example, the researcher denoting the current project on KM would document explicit knowledge ("the statements must contain two of the three words in related statement or set of statements") about the criteria by which *Knowledge Capital Theories* are tagged with the KCT.

The relationship between denotation tags and textual data items is many-to-many. This means one instance of text can have many tags and one tag can have many instances of text in a body of dialogue. Figure 4 shows specific examples of each, and depicts the complexities that can arise in extracting meaning from textually represented knowledge.

TRANSFER TO USABLE MEDIUM

Use of denoted data, stored as shown in Figure 4, can be tedious and time-consuming in knowledge work like literature reviews. For this reason, and due to advances in relational database technologies, it can be said that conversion to a relational format is desired (and is, coincidentally, a natural process). Figure 5 shows the result of this conversion, a relation logically depicting which literature work is associated with a given concept.

Conversion can be done with or without further analysis, which presents the opportunity for a KM specialist to convert tagging instances to any of the four data types (nominal, ordinal, interval, or ratio). For example, Figure 5 shows that the specialist may input ratio data which may represent the number of times *History* (HIS) is tagged in a specific work. It is shown that *Definition of KM* either does (DEF = 1) or does not (DEF = 0) exist in a given title and is therefore represented nominally. Qualitative data in this case is more appropriate for *Definition of KM* since multiple definitions of KM usually do not usually appear in text sources. The definition of the data type of a concept can be important, because qualitatively defined concepts have implications for the range of capabilities associated with hypertext links between concepts and text instances.

	SO	**ST**	**AB**	**EM**	**HIS**	**DEF**	**…**
Title1	Book	Field	Academic	Conceptual	0	1	…
Title2	Dissertation	Field	Practitioner	Empirical	1	0	…
Title3	Book	Case Study	Academic	Empirical	1	1	…
Title4	Periodical	Blue Sky	Academic	Conceptual	3	1	…
…	…	…	…	…	…	…	…

Figure 5. Relational Representation of Denotation Instances

More elaborate examples of concepts where a qualitative design is appropriate are those of *Study Type* (ST) and *Empirical Support* (EM). For example, upon conversion from denotation, *Study Type* may be coded as a field study, case study, multiple case study, etc. These examples show the richness by which denotation can be captured in relational format, and also the inevitable reliance the intuitive feel of knowledge workers operating the methodology depicted.

Use of Ontology

The storing of denotation in relational form implies that normalization decomposition procedures can be performed on the data in the production of a KM production database. The goal of such a database is to relate a knowledge manager to literature corresponding to good and bad practice in the field, a KM Best Practices Database (KM-BPDB). A data-driven approach to using the KM-BPDB would involve sorting values to find where knowledge about a particular concept exists in the literature. A researcher on KM [Barclay and Murray, 2004]

Table 4. Instances of the *'Definitions of KM'* Ontology Element

KM 'Guru' Source	Definition of KM
Thomas Bertels	the management of the organization towards the continuous renewal of the organizational knowledge base - this means e.g. creation of supportive organizational structures, facilitation of organizational members, putting IT instruments with emphasis on teamwork and diffusion of knowledge (as e.g. groupware) into place.
Denham Grey	an audit of "intellectual assets" that highlights unique sources, critical functions and potential bottlenecks which hinder knowledge flows to the point of use. It protects intellectual assets from decay, seeks opportunities to enhance decisions, services and products through adding intelligence, increasing value and providing flexibility.
Brian Newman	Knowledge Management is the collection of processes that govern the creation, dissemination, and utilization of knowledge
Karl-Eric Sveiby	the art of creating value from an organization's intangible assets.
Karl Wiig	focusing on determining, organizing, directing, facilitating, and monitoring knowledge-related practices and activities required to achieve the desired business strategies and objectives.

would use this query to build one ontological specification of the field or to discover associations and terms much faster than with traditional research approaches. For example, the user may wish to review all Definitions of KM for further ontological refining as is depicted in Table 4.

A goal-driven approach may include powerful, drill-down capabilities built into the database in the form of querying languages, embedded scripts and external applications. For example, we may wish to review all articles containing both *KM Characteristics* (CH) and *How Technology Can Support KM* (TECH) using SQL capabilities. Management can use the ontological schema to segment work activities in a knowledge model, so that practices and technologies can be researched for a given work setting (much like how software support personnel work currently). In the face of enormous growth in online textual data, these examples show how the process of transforming ontologically specified elements to relational format can support the conceptual decision-making activities of strategic management. Last, systems can be built with capabilities to perform ontological specification, denotation, and transfer to standard relational data structures, and processing of electronically held textual knowledge.

V. VALIDATION OF FINDINGS

The concept of OSP was first presented at the 'Knowledge-Based Systems for Knowledge Management in Enterprises' workshop at the *21st Annual German Conference on Artificial Intelligence 1997* (http://www.dfki.uni-kl.de/km/ws-ki-97-schedule.html). At the time, the topic centered primarily on ontological specification. Based on face-to-face feedback from that conference and other subsequent interactions with academic colleagues, it was determined that the development of a software tool might offer opportunities to validate the ontological specification concept. The AI conference represented the first evidence of validation of the ontological specification concept.

Over the years, several attempts by the primary researcher to build software to support OSP failed, primarily because it was done independently, in relative isolation, and limited to a theoretical description of the essential concepts (i.e., the paper presented at the aforementioned AI conference in Germany). It was eventually determined that the action research approach held promise as providing a validated system that was enriched by the original OSP concepts. Using an iterative prototyping approach, the project embarked using one faculty member and one doctoral student, each in MIS. In this first phase, the faculty member served as the researcher-designer and the student acted as a user-subject. Early in this phase, it was determined that Microsoft's Excel spreadsheet would serve as a fitting technology with which to base the system. Some primary characteristics of Excel that were appealing to the design team included 1) ease of development, 2) relational data representation, 3) widespread popularity, installation, and proficiency in the academic community, 4) wide range and accessibility to functionality, and 5) prospects for a steep learning curve in use and user development. The goal of the research was to demonstrate the usefulness of the OSP concept in a real world object, which was manifested by the creation of an Excel-based prototype. We named this prototype the *ontological specification system* (OSS), which is a technology-mediated embodiment of the OSP concepts illustrated above. Consistent with action research principles, the theoretical meaning of OSP was used to inform the construction of the OSS.

STRUCTURED INTERVIEWS

To evaluate the system, users were shown a presentation depicting the use of the system and then sent a file containing the example shown in our illustration. Four user-subjects participated in a computer-mediated walk-through consisting of PowerPoint and Excel files to demonstrate the theoretical concepts and evolving prototype. As Ph.D. students in MIS, each subject was very familiar with Excel, ontologies, and the OSS application area (academic writing). We found that the presentation was fully adequate to allow each subject to understand the OSS.

Each interview lasted approximately 30 minutes and resulted in several suggestions for improvement. Several changes deriving from these sessions resulted in significant changes to the system. Interviews were conducted individually and sequentially, allowing changes to be made before subsequent interview sessions could be held. Generally, each additional interview session resulted in less change, and the final interview resulted in very slight change. For that reason, it was determined that four subjects was an adequate number in the context of this project.

STRUCTURED QUESTIONNAIRE

The final phase in the session was the administration of a structured, open-ended questionnaire at the end of each interview. The questionnaire intended to acquire explicit feedback regarding system and user attributes (see Appendix II). This questionnaire was constructed based on 3 important perspectives: user demographics (questions 1-3), perceptions of system usefulness (4-7), and perceptions of the ability of the system to support collaborative work (8). Last, users were asked to provide input regarding possible system improvements (question 9). The following paragraphs provide summaries of the responses based on each attribute (actual responses are provided in Table 5).

Regarding *demographics*, the subjects of this research are Ph.D. students at a U.S. state university. Three of the subjects are currently working on their dissertation, and one of them is in the coursework stage. The average academic research experience of the subjects is 3.5 years and the subjects reported having completed an average of 30 pages of literature review.

Regarding *usefulness*, respondents generally indicated that they believed the system is useful. Respondents answered that the system will reduce their learning curve, assist in recalling literature, and help organize the literature. These beliefs manifested themselves in three different subconstructs of usefulness. First, the respondents indicated that they perceived the system to have *ease of use*. We believe the ease of use of this system stems from the fact that it is user-

Table 5. Actual Responses from User-Subjects

System Attribute	Subject 1	Subject 2	Subject 3	Subject 4
Usefulness	It would help categorize thoughts. I could see this system to maintain a master file of all literature review that I ever did. Such a system would be advantageous by reducing the learning curve and assisting in recalling literature.	Planning and forming discussion threads Time management	Help organize the literature for writing the script. Sorting and categorization is very useful.	The system is useful in developing research papers in general. When organizing support for assertions, theories, and models, the system will provide the most utility. This system will not only be useful for crafting research papers, it is also useful in analyzing them.
Ease of use	I am familiar with the features of Excel and Word that allow for the breakdown of a literature review or paper.	Developed from Excel No complicated procedures Conceptually intuitive	Familiarity with Excel Flexible list	It breaks papers into more manageable sections, then into sentences. Because the paper is analyzed or constructed one sentence at a time, there is less strain on the user's cognitive capabilities. Instead of recalling all of the author's references to a particular theory or model, the system can sort the paper into groups of references to particular topics. That it runs in Excel makes it easier to use, instead of learning a totally new interface, users will just learn a new functionality in familiar software.
Difficult	In many cases the large number of records present in such a system could make it cumbersome and difficult to use.	Some Excel features are not "basic"	Long sentences hard to read on the horizontal layout Can have conflict with ENDnote. Need to coordinate if used for collaborative research projects.	Reading one sentence at a time is not as intuitive as reading the entire paper. Until I have developed the requisite skills for quickly categorizing sentences, it will take longer than traditional methods.

Table 5: Actual Responses from User-Subjects (continued)

System Attribute	Subject 1	Subject 2	Subject 3	Subject 4
Overall	It could be useful in organizing and perhaps more importantly maintaining knowledge regarding a particular topic. In fact, such a system could prove beneficial in organizing literature for comps and then after comps the system could be used to quickly recall cites when conducting research.	It has the potential to be very useful for both manuscript creation and reengineering. I liken it to useful extension to EndNote.	New application built on existing skills. Easy to learn. Almost no extra cost.	There are many advantages to using this system. If adoption of this method is slow, it is because users are not comfortable decomposing a paper into sentences. However, the learning curve associated with this method should be relatively steep for authors and reviewers of research papers; they are used to considering a single statement or sentence at a time. Law students could also use this method to decompose case reviews or legal documents into more manageable parts for further analysis.
Suggestion	It might be nice to automate the procedure for moving data between Word and Excel.	Consider developing an interface that is less “Excel like” and more platform independent.	How to make it work more easily for cross-reference between different papers?	Improvements to this system should cut down on the time it takes to decompose or build a paper. Create a function which automatically parses a paper into sentences, and deposits each sentence into an Excel box. Also, create a function which constructs paragraphs based a selection of sentences in Excel.
Collaborative Research	It could. Assuming that all parties had knowledge of how to use the system, it could be useful to create and edit papers.	No doubt. Although everyone has their own methods and support tools for developing research, I see it as a useful alternative. I believe it is just as useful on a group level as it is on an individual level. The only problems may occur in making sure that everyone is using the system properly and completely as to not “withhold” content.	Yes Exchange organized literature review, storage of them for other papers.	This system will aid group collaboration. It would be easier to identify sentences or groups of sentences which need modification with the new system.

developed using familiar spreadsheet software. Therefore, very little additional effort on the part of the subjects is needed to use the system. Second, the respondents pointed out several *difficulties* regarding system use.

One of the shortfalls of the system remains the difficulty of reading long sentences in Excel, where users need to adjust the cell widths for long sentences. This is not what users are accustomed to in most other software, although it can be alleviated in the flexible Excel interface. Third, *respondents summarized the usefulness* of the system. Important towards validating the system, the respondents found it potentially useful and promising in their future research.

Finally, Table 4 indicates that there is consensual agreement among the user-subjects that the OSS would be useful in collaborative projects. However, successful collaborative use depends on familiarity among members with OSS. One user-subject warned that each user would have his/her own methods within the OSS environment. In our experiences, this required very little coordination between researchers in projects involving academic manuscripts.

Based on feedback from interviews and questionnaires, the OSS was judged to be a valid contribution to MIS knowledge. The theoretical lens for the creation of the OSS was OSP. Thus, the OSS prototype was used to validate OSP through iterative refinement. OSS was used experimentally for various purposes in the development of academic manuscripts by the researchers, both as a part of and separately from the research project articulated here. Many lessons learned from trials of evolving versions of OSS resulted in changes to, and subsequently the validation of, the system by users and researchers.

VI. CONCLUSIONS

This paper validates an approach that holds great promise in supporting of a wide range of content analysis applications: ontological specification processing. The need for developing systematic content analysis methods such as OSP derives in part from the proliferation of information technology, which has caused increased dynamicity in workplaces and organizational environments. This research attempts to show how the use of information technology, through the development of an OSS, can help respond to such challenges. In particular, we conclude that the application of OSP and OSS could help greatly in the growing area of content analysis, a promising focal point for strategic competitive advantage [Nemati and Barko, 2003].

OSP involves the construction and presentation of specific meanings, as derived from more general concepts, in a knowledge domain. It is our intention that ontological specification tools such as the OSS prototype promise to improve academic research, particularly in early stages. In the context of the academic publishing process, we believe the system is most useful for compiling an original set of notes and major revisions and least useful for minor revisions. Kuhn (1970) has referred to the early stages of epistemological development in a knowledge content domain as ‘revolutionary’ because of its relative instability. To illustrate, we applied OSP to the topic area of knowledge management because its literature is in the concept formation stage. We found that the KM literature contained many references to prescriptive concepts in descriptive research. Further, the literature on KM is characterized by predominantly non-academic sources and little understanding of variables and the relationships between them. The OSP allowed for the extraction and organization of the most important and potentially fruitful concepts of interest in KM.

Validation of the OSS was a second important contribution of this research. OSS is an Excel-based environment that depends heavily upon end user development throughout its use. In general, the system supports the production of structural meanings in content domains within knowledge domains. We used the OSS to create and use ontologies from individual concept elements, which were subsequently used to label sentences in the writing of academic manuscripts. We foresee that the OSS will be useful in the development of a single or a series of manuscripts and easily facilitates collaborative research.

Within the context of MIS practice (in addition to MIS academic research as illustrated), we foresee two distinct uses of the OSS. First, we have shown that the OSS can speed the OSP, which has significant implications for supporting content analysis. Content analysis is used in the requirements definition phase of systems analysis and design to structure meanings of a problem domain. As illustrated in this research, OSP and OSS supports the cognitive tasks associated with the deduction of logical structures, commonalties and relationships in conceptual representations found in textual data.

Second, the hierarchical nature of ontologies holds a great deal of promise for data structuring and normalization. The prospect of transferring ontologically derived concepts to databases is very appealing and feasible. It has long been held that databases are much easier and efficiently created, operated and maintained when the data is held in logical structures. The process of normalizing a relation has this purpose and is relevant when the data is held in relational format.

Based on our experiences, we believe that the most important determinant of 'MIS success' (Delone and McLean, 1992) accompanying the OSS is its *ease of development*, which is offered by the Excel application environment. The adaptive and flexible nature of Excel greatly facilitates ongoing end user development needed to satisfy changing user requirements between and within projects.

Further research is needed to determine the extent to which OSS may aid in the area of normalization. It is evident that normalization follows a very similar decomposition process as that found in the ontology presented and new elements of the field can be uncovered in that process. Further, the notion that an ontological notation scheme should consist of unique values suggests that a given ontology lends itself to the application of a production database scheme, where concepts are records and properties can be generated that describe important dimensions of the field.

Editor's Note: This article, which was fully peer reviewed, was received on February 22, 2005 and was published on April 7, 2006. It was with the author for 1 revision.

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EDITOR'S NOTE: The following reference list contains the address of World Wide Web pages. Readers, who have the ability to access the Web directly from their computer or are reading the paper on the Web, can gain direct access to these references. Readers are warned, however, that

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APPENDIX I. ACRONYMNS

AI – Artificial Intelligence
ANOVA – Analysis of Variance
CASE – Computer Aided Software Engineering
CEO – Chief Executive Officer
DSS – Decision Support Systems
HTML – Hypertext Markup Language
IS – Information Systems
ISA – Information Systems Architecture
IT – Information Technology
KM – knowledge management
MIS – Management Information Systems
OSP – ontological specification process
OSS – ontological specification system
SQL – Structured Query Language
Note: many capitalized word fragments in the text are mnemonic tags, not acronyms

APPENDIX II. USER-SUBJECT QUESTIONNAIRE

* This questionnaire is for research purposes only. Your participation is voluntary. Individual responses are anonymous and will be held in strictest confidence. Thank you for your help.

1. In what phase in the Ph.D. program are you?

    Coursework Comp Dissertation

2. How many years have you done academic research?

3. Approximately how many pages of literature review have you completed in your life?

4. How is the system useful in your research?

5. What makes the system easy to use?

6. What makes the system difficult to use?

7. Overall, what do you think about this innovation?

8. Do you think the system can help you work with others when doing collaborative research projects?

    How?

9. What are your suggestions for improving the system?

Thank you for your participation!

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Communications of the Association for Information Systems

ISSN: 1529-3181