THE MANAGEMENT AND ORGANIZATION OF KNOWLEDGE: A THEORY AND PROTOTYPE IMPLEMENTATION

by

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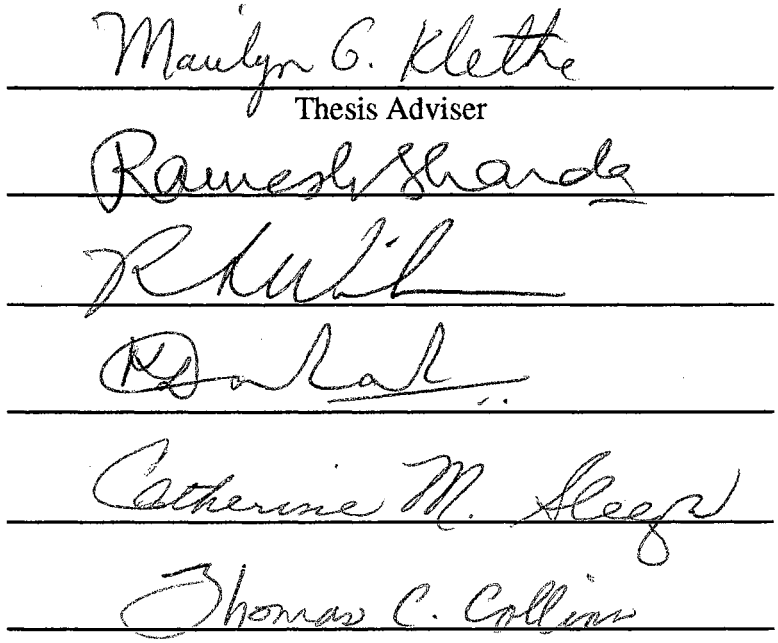

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CHAPTER I

INTRODUCTION & OBJECTIVE

1.1 Introduction

The knowledge resource is becoming increasingly more important as a vital strategic tool to improve organizational decision-making and problem-solving capabilities. To ensure competitiveness, organizations need to capture and store relevant knowledge. To subsequently utilize the stored knowledge, it needs to be distributed to those who will be able to use it. Making sound use of both external and internally available knowledge will enhance organizational performance in today's dynamic business environment.

However, if organizations are to more effectively develop and use their knowledge, the concept of knowledge has to be made more specific and put in an operational context. This research, therefore, examines the nature of knowledge and how it can be managed and organized. A working theory of knowledge, knowledge utilization, knowledge management, and knowledge organization were developed, all of which resulted in a general knowledge organization structure. To test the use of this knowledge organization structure, it was subsequently implemented as a software application prototype for the organization and retrieval of one particular type of knowledge, training materials.

1.2 Objectives

This dissertation research has five interrelated objectives. The first two objectives relate to general theory development, while the other three relate to the application of this theory to the development of a prototype for a particular implementation.

The objectives are:

1. The development of a general theory of knowledge, knowledge manipulation, and knowledge organization.
2. The development of a general knowledge organization framework as it emerges from the developed theory.
3. The development of a particular instance of this knowledge organization framework for a specific application area, this being the area of corporate training.
4. The development of an automated prototype which implements the framework instance in the chosen application area.
5. The testing of the developed prototype in a corporate setting.

The first two objectives relate to the development of new theory and the final three test the validity and usefulness of the knowledge organization portion of the theory in a single instance. The final three objectives were accomplished using a prototype application which provided for the organization, selection, and distribution of pieces of knowledge, which in this instance consisted of training materials. This study examined whether the prototype served as an "intelligent" database for these materials. Given this purpose, the prototype would have to perform the following functions:

- Organize a given set of knowledge fragments (units) according to the developed knowledge organization framework into an accessible database.
- Provide an index or overview of the available units.
- Accept a set of objectives for training purposes.
- Select the appropriate units or unit-sequences.
- Output a list of the found units or unit-sequences.

A visual overview of this prototype is provided in figure 1.

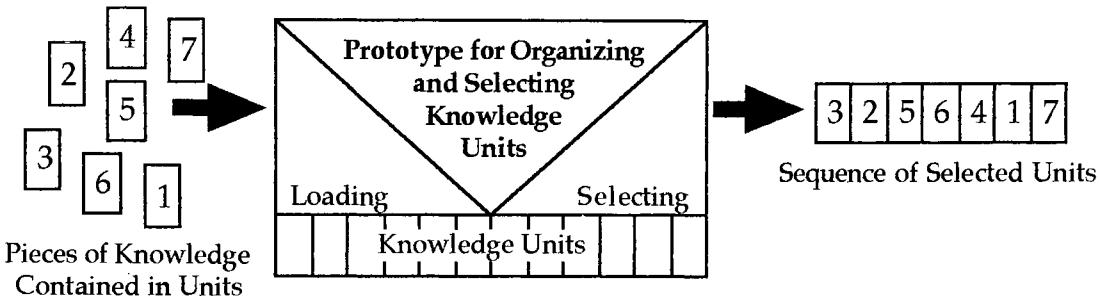


Figure 1. Prototype Overview

1.3 Original Contribution

The following are the project's original contributions to the information systems discipline:

- Theory development in the area of knowledge, knowledge manipulation, and knowledge organization.
- The design of a general knowledge organization framework.
- The design and development of a prototype to demonstrate the use of the knowledge organization framework.
- The preliminary testing of this prototype in a corporate setting.

1.4 Relationship of this Research to the Information Systems Discipline

1.4.1 Theory Development

One aspect of the information systems discipline is to describe, evaluate, and improve the processes of information gathering, organization, storage, communication, distribution, manipulation, and use. The substance of information - and its unprocessed form called data - is the raw material of information systems. (Alter, 1992, p. 81)

A case will be made, however, that knowledge is a concept broader than information and is highly relevant to many decision-making and information processing situations. The distinction between the holistic nature of knowledge and the narrower nature of information is made in section 2.3. There it is argued that information systems theory should strive to gather, organize, store, communicate, distribute, manipulate, and use knowledge rather than merely information. The reason for this is that the application of knowledge, rather than of data or information, could - when put into practice - lead to improved decision making.

1.4.2 The Application Prototype

An important applied function of the information systems discipline is the support of information processing and decision making by integrating information technologies with organizations and the people working in them. (Alter, 1992, p. 7) The application prototype built in the course of this project has essentially a similar objective, but with respect to knowledge rather than information. The application facilitates the utilization of knowledge for knowledge assimilation and intelligence gathering purposes. As such, the application relates to some important issues addressed by the information systems discipline, particularly in the area of decision making.

One goal of Information Systems is to improve individual and group decision making. The model often considered in this context is Herbert Simon's decision making model. (Simon, 1977) In this model, the three elementary phases of decision making are Intelligence (the gathering of information relevant to the decision), Design (the modeling of the decision situation which leads to the identification of criteria for the evaluation of alternatives), and Choice (the making of the actual decision).

The application prototype relates most closely to the intelligence phase. While the application is not specifically designed to support any particular decision, it supports the gathering of knowledge for training and assimilation purposes to enhance decision-making capabilities.

1.5 The Potential for Practical Application

While the initial objective of this project is to develop theory in the area of knowledge definition, manipulation, and organization, the application of this theory should eventually extend to the actual implementation of an organization's knowledge architecture. The application prototype which was developed based on the theory is an initial attempt to realize this. The application was tested in an organization which develops managerial training and development materials.

The immediate target for the application prototype, then, is the area of organizational training. The materials contained in the application's database will be training materials which each address a particular training need or objective. As such, the application prototype has the potential to become a useful tool for an organization's Human Resources Development function. HRD-employees could load a system based on the application prototype with all the organization's training materials, and could then use it to build customized training modules for individual workers. The added advantage to this approach is that all training materials would be organized at one single point in the organization from which they could be distributed. Thus, given the applied knowledge organization structure it would be easy to determine what training materials are available and what gaps still need to be filled with new training materials. Finally, integration of all an organization's training materials would likely encourage a consistent and effective approach to developing training materials.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The first and primary objective of project is the development of a broad theory of knowledge, knowledge manipulation, and knowledge organization. This theory will integrate findings and practices from a variety of sources. To this end, a broad survey of the available literature was performed. This chapter, then, presents current theory and empirical findings on the topic of knowledge and covers the following four aspects:

- Section 2.2 describes why the topic of knowledge is relevant to organizations.
- Section 2.3 provides an overview of different descriptions of what constitutes knowledge which will be used later to develop a general definition of knowledge.
- Section 2.4 describes existing literature and practices of knowledge utilization and management.
- Section 2.5 discusses the need for and general philosophy of knowledge organization and gives an overview of existing knowledge structures.

2.2 Beyond Information

The application of new data types to decision making processes within organizations demands a new perspective on the materials contained in computers and information systems. Multimedia materials, for example, generally are richer and more complex than the factual data contained in traditional computerized databases. In fact, they alter the possibilities of existing information systems to such an extent that even the term information no longer seems entirely appropriate. The word which appears to most

completely describe the full potential of such materials is **knowledge**. Knowledge encompasses simple facts, expert opinions, accumulated experience, problem solving procedures, etc., in many possible shapes or forms.

Organizations have come to realize that knowledge, as elusive as it may be, is a property worth taking care of. (Wiig, 1988) This, then, would lead one to assume that knowledge and the management of it provide value to the organization. Much like information, knowledge has little value unless it is shared and used. The management of knowledge, therefore, should improve the communication of knowledge which allows the organization's workers to transfer insights, experiences, and expertise, thus broadening the workers' view beyond the boundaries of their specialization. This, in turn, may nurture creativity and innovation in the organization for the purpose of improving organizational performance.

Wiig (1988) describes the value of knowledge as a function of the extent to which an organization is able to exploit the available knowledge towards fulfilling its goals. In more operational terms, for business and industry this translates into the contribution of knowledge towards profitability and competitive advantage. Effective use of knowledge allows the organization to be more responsive to market demands, to more rapidly absorb innovations, and to be more flexible in its production. In addition, both the efficiency and the quality of organizational processes, products, and services could be improved given effective knowledge. (Case, 1991) In the short term, this allows an organization to increase its market share and improve its economic health. In the long term, the organizational survival is positively affected.

Wiig (1988) points out that not all knowledge is of equal value. Knowledge that is easily acquired (such as publicly available knowledge) often does not contribute much to competitive advantage. In contrast, knowledge that is rare or difficult to obtain (not only

for the organization but also for its competitors) is often of high competitive value.

The use of a valuable organizational resource, such as knowledge, requires a systematic approach. However, until now few authors have explicitly and formally considered the management and exploitation of knowledge. The following sections, then, cover the various strands of research and practice in the area of knowledge, its utilization, its management, and its organization.

2.3 Defining Knowledge

2.3.1 Introduction

Knowledge could simply be described as what a person or an organization needs to comprehend to operate effectively and efficiently. This description, though, is hopelessly short on the richness of knowledge and the many ways in which it can be used. Knowledge is a much broader concept than data, the facts and figures which still drive many organizations. Knowledge even goes beyond the concept of information, which is generally defined as data which has been aggregated and processed into a more usable form. (Alter, 1992, pp. 81)

When considering examples of how knowledge is being used in organizations, it becomes apparent that many pieces of knowledge exist outside conventional organizational databases. For instance, organizational knowledge is contained in memos about organizational developments, articles in a trade journals on the organization's industry or technology, proposed solutions to organizational problems, manuals for operating or trouble-shooting machines or computers, the results of a marketing survey, or in the accumulated experience of salespeople, process controllers, designers, and engineers.

Knowledge, then, has both a breadth and a richness to it, given that it can be represented in many forms and media, and can be either static or dynamic. It is difficult to formalize specifically and may therefore appear to be quite elusive. However, as the previous examples indicate, knowledge is an indispensable component of organizational activity. It is therefore necessary to at least organize the concept of knowledge so that it can be better used in specific organizational contexts.

The following five sections describe five different conceptualizations of knowledge - five attempts to define this seemingly elusive substance. The combination of these five conceptualizations will result in a broad, holistic view of what constitutes knowledge, that will subsequently be reflected in the definition of knowledge in the knowledge theory delineated in chapter 3. The first of these conceptualizations is the most restrictive one; based on traditional data modeling, it attempts to view knowledge as a combination of pieces of data. The following four conceptualizations broaden the perspective of what constitutes knowledge and attempt to describe those properties which distinguish knowledge from data or information.

2.3.2 Knowledge Conceptualization using Traditional Data Modeling

While the definition of knowledge is still fuzzy, the concept of data has been quite well defined. A starting point for defining knowledge, therefore, would be to examine what constitutes data, how pieces of data can be combined into information and, eventually, how a definition of knowledge can use some of the data modeling concepts.

The concept of data, defined as "facts that can be recorded and that have implicit meaning" (Elmasri & Navathe, 1989, p. 3), has long been incorporated into database architectures. The hierarchical, network, and relational database architectures have used increasingly sophisticated data modeling techniques to more fully capture the essentials of

real-world entities in a database. Of such modeling techniques, the Entity-Relationship (ER) model is probably the best known and most widely applied. This high-level conceptual data modeling technique is used in database design to specify the structure of a data set to be contained in a database. (Elmasri & Navathe, 1989, p. 37) While this technique (as well as other data modeling techniques) is limited to the more traditional definition of data, it does provide some insights in how to view the concept of knowledge.

As its name implies, the ER-model considers both entities and relationships. Entities are defined as things or objects "in the real world with an independent existence" which can be described by a set of properties, called attributes. (Elmasri & Navathe, 1989, p. 41) An entity can be a composite and so contain a set of entities, each with their own attributes. Relationships are defined as sets of association among different entity types (Elmasri & Navathe, 1989, p. 47).

Despite being limited to data, the ER-model has the potential to apply to the description of knowledge as well, particularly in the distinction it draws between entities and their describable relations. The limitation of the model is that it lacks in the description of processes and other time-based types of knowledge. While a process could be considered an entity in the ER-model, this hardly captures its dynamic nature and its continuous properties.

2.3.3 Alter's Conceptualization of Knowledge

Continuing from the definition of data towards a definition of knowledge is the conceptualization developed by Alter (1992). Alter defines knowledge as it can be distinguished from data and information. Data are defined as facts which may or may not apply to a given task. Information is data which has been processed in order to facilitate their use. Knowledge, then, is "a combination of instincts, ideas, rules, and procedures that

guide actions and decisions." (Alter, 1992, p. 81) Alter places these three concepts in a model based on systems theory. In this model, shown in figure 2, data serves as input to the process in which data is transformed into information in order to support decision-making. The output of the process is the result of the actions which follow from the decision. The comparison of the actions and the results provides feedback about the methods used to process data, interpret information, and make decisions. This feedback is what constitutes knowledge. Most of this knowledge resides with the people in the organization, but some of it may be made explicit and incorporated in the organization's information-processing and decision-making procedures. (Alter, 1992, pp. 82-83)

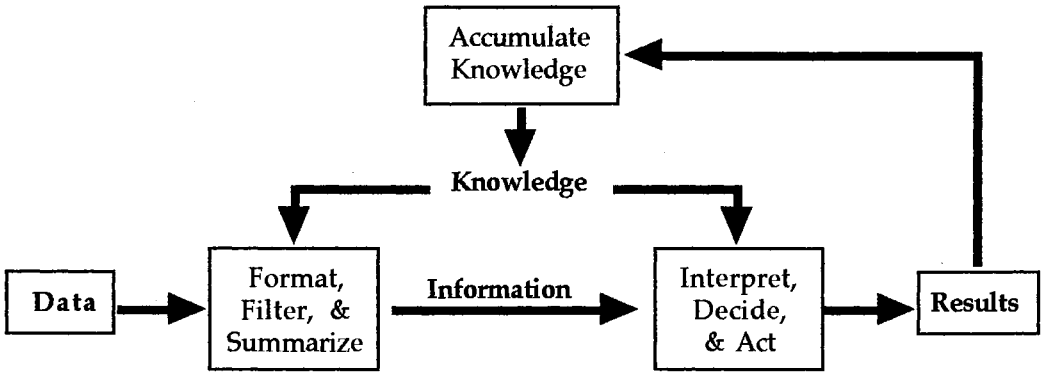


Figure 2. Alter's Conceptualization of the relationship among data, information, and knowledge

Alter's definition of knowledge sets it apart from both data and information by presenting it as a meta-entity. Knowledge, in this conceptualization, can be compared to the idea of experience. It guides the actions of information processing and decision making based on past events. In Alter's model, then, knowledge does not directly relate to a certain decision to be made or a problem to be solved, but rather to the process of decision-making or problem-solving. In short, knowledge relates to the process, not to the content of a particular issue. This obviously limits the concept of knowledge.

2.3.4 Badaracco's Conceptualization of Knowledge

Alter's description of what constitutes knowledge (see section 2.3.3) is restricted to process-related aspects. Badaracco's description of knowledge includes both content and process elements. Badaracco (1991) contends that knowledge is so pervasive that it can be found in an organization's "technology, innovation, science, know-how, creativity, information." (Badaracco, 1991, p. 1) In this conceptualization, knowledge can be classified as being either migratory or embedded.

Migratory knowledge is mainly content-oriented knowledge that is clearly articulated. Given this clarity, this knowledge is easily disseminated as it is represented in "formulas, designs, manuals, books, or pieces of machinery." (Badaracco, 1991, p. 1) According to Badaracco, this type of knowledge "can migrate with extreme rapidity and it can migrate in several directions at once." (Badaracco, 1991, pp. 9-10)

Embedded knowledge is mainly process-oriented knowledge that resides in complex social relationships and is far less specific than migratory knowledge. Often a team, department, or company "knows" something collectively that is not specifically known by any individual member, possibly because the knowledge involves the combination of various proficiencies. (Badaracco, 1991, p. 10) Craftsmanship, expertise, and the outcome of a group decision-making process are examples of embedded knowledge. Badaracco's embedded knowledge, then, can be viewed as extending Alter's description of knowledge as information-processing and decision-making experience.

2.3.5 Wiig's Conceptualization of Knowledge

An even more holistic description of knowledge is put forth by Wiig (1988). In this conceptualization, knowledge is defined as "justified beliefs about the truth or efficacy

of facts, principles, and methods." (Wiig, 1988) This definition appears similar to Alter's conceptualization of knowledge as a meta-entity. Wiig then expands this definition by considering knowledge from two dimensions. First, Wiig (1988) distinguishes the following three broad types of knowledge which differ in the extent to which the knowledge is shared with others:

- **Public Knowledge** is knowledge which is readily available in a published format, such as in books, periodicals, and other public documents. This type of knowledge is clearly comparable to Badaracco's concept of migratory knowledge.
- **Expert Knowledge** is the expertise that is commonly shared among specialists in a particular field. This type of knowledge is comparable to Badaracco's embedded knowledge.
- **Personal Knowledge** is knowledge that is often not shared. This includes personal opinions and thoughts which are sometimes difficult to express in specific terms. Personal knowledge, too, relates to Badaracco's description of embedded knowledge.

Wiig (1988) then considers the following four categories of knowledge as it increases in abstraction and complexity:

- **Facts & Data** are rather exact pieces of data pertaining to a particular issue.
- **Perspectives** are people's points-of-view about an issue.
- **Hypotheses** are personal expectations, insights, and interpretations about a particular issue.
- **Reasoning Strategies** are the particular methods of diagnosis and synthesis used by experts. These methods of reasoning are often not made explicit.

Wiig's framework leads to two significant conclusions about organizational knowledge. First, the full set of organizational knowledge is likely to extend far beyond the contents of conventional information systems. Information systems commonly contain facts or data structured into fixed database fields or dependable rules and procedures, which mainly represent the public knowledge type. While such factual knowledge is rather easy to obtain and codify, an organization is likely to need knowledge from all types and categories to achieve its objectives. However, expertise, hypotheses, points-of-view, etc., are often difficult to capture, codify, and fit into conventional information systems applications.

Second, much of this needed knowledge is nevertheless present within the organization; however, it resides with people. Perspectives, expectations, insights, expertise, and opinions are held by the people working within the organization, often in the form of experiences, stories, and anecdotes. (Brown, 1991) Conventional information systems are generally incapable of containing such knowledge: much of it is descriptive, rather than in the form of fixed database fields or explicit expert-system rules. In addition, this knowledge generally is not shared over formal telecommunications lines, but rather through interpersonal contact. Initially, the organization is able to nurture, develop, and utilize this knowledge through the development of its human resources. However, given that employees change jobs, retire, or may suddenly be incapacitated, it is likely that organizations will consider using technology for the capturing, storing, and disseminating of this knowledge. Nevertheless, the human aspect of knowledge development should not be overlooked.

2.3.6 Knowledge Representation in Artificial Intelligence and Expert Systems

The gathering and application of knowledge is an important aspect of the field of artificial intelligence (AI), and particularly of its subfield of expert systems (ES). The goal

of the artificial intelligence field has generally been stated to be the creation of computers and/or programs which perform or mimic human thought and reasoning. (Turban, 1992, p. 4) However, the goal of the expert systems field, which can be viewed as a subfield or operationalization of artificial intelligence, is generally held to be the capture of knowledge and expertise for the purposes of distribution and application. (Zahedi, 1993, pp. 38-39)

Two broad categories of knowledge have been developed in the ES/AI field. These two categories can be differentiated by the manner in which the knowledge was obtained and consequently the way in which the knowledge is represented.

The first category of knowledge can be referred to as explicit knowledge. (Zahedi, 1993, p. 541) The gathering method of explicit knowledge is generally referred to as knowledge engineering. In knowledge engineering, knowledge engineers extract the knowledge relevant to a particular topic or objective from human experts through interviewing and process observation, and from existing sources such as books and documents. The resulting knowledge is then organized, verified, and converted into a format which an expert system application can use. (Turban, 1992, pp. 118-119)

Two general formats are used for explicit knowledge: a logical format and an object format. The logical format displays the knowledge in the shape of production rules, organizing precedent and antecedent states in "if ... then ... else" form. (Hayes-Roth, 1985) The object format, commonly referred to as frames, displays the knowledge as a set of values for a matching set of attribute-types. (Fikes & Kehler, 1985) Either format, or a combination of these (Turban, 1992, p. 221), can be used by an expert system for inferencing purposes, such as diagnosing a problem or making a recommendation. The essence of explicit knowledge is that it requires human collection and interpretation efforts to develop and that the resulting knowledge can easily be read, comprehended, and verified by people familiar with the content area.

The second category of knowledge can be referred to as implicit knowledge. (Zahedi, 1993, p. 541) This category of knowledge is usually from a data set by an automated process, such as the ones used by neural networks or inductive learning. In this inferencing process, an application accepts a data set and through an algorithmic procedure attempts to extract relevant patterns from the data. These patterns can then be used by a companion application for the purposes of diagnosis or decision-making. (Turban, 1992, pp. 631-633; Zahedi, 1993, p. 135)

Given that implicit knowledge does not require direct human interpretation to develop, its format generally does not support easy comprehension by people. Implicit knowledge can be represented as weights in a network, as is the case with neural networks, the values and function of which are not readily suited for interpretation. (Zahedi, 1993, p. 541) Another common implicit knowledge format are the shape and branching criteria of decision trees resulting from inductive learning. Although the function of a decision tree can easily be comprehended by people, the verification for the manner in which the algorithm constructed the decision tree is often more difficult to grasp. (Zahedi, 1993, p. 135)

The manner in which the AI/ES discipline conceptualizes knowledge echoes two themes from the previous sections. First of all, the AI/ES conceptualization of knowledge recognizes that knowledge - particularly expert knowledge - is valuable, and that therefore it is beneficial to an organization to capture it to enable broader application of the knowledge. (See section 2.2) Indeed, Expert Systems texts often mention the capture and distribution of scarce expertise as an important reason for ES-development. (Turban, 1992, p. 95; Zahedi, 1993, p. 39)

Second, the AI/ES conceptualization recognizes that knowledge resides primarily with people, but that it can also be obtained or extracted from various other sources such as documents, processes, etc. This is similar to Badaracco's embedded knowledge (section 2.3.4) and Wiig's three knowledge types (section 2.3.5). The AI/ES conceptualization of knowledge, however, is not as broad as those by Badaracco or Wiig in that AI/ES applications have generally been developed for very narrow and specific knowledge domains. (Turban, 1992, p. 98)

2.4 Knowledge Utilization and Management

2.4.1 Introduction

Merely possessing knowledge is not enough to realize the value it can bring an organization. To realize its benefits, knowledge needs to be applied to a particular decision-making or problem-solving process. This application, then, requires that the knowledge be made available. These two sets of processes will be distinguished as knowledge utilization and knowledge management. Knowledge utilization - for the purposes of this project - is described as the manipulation of a collection of knowledge for the purpose of applying it to a decision-making or problem-solving situation. Knowledge management - for the purposes of this project - is be described as the control and administration of the organizational knowledge collection to ensure its availability when the need for knowledge application arises. Existing theories of knowledge utilization and knowledge management processes are reviewed in the following two sections.

2.4.2 Knowledge Utilization Processes

Because the definition of exactly what constitutes knowledge is still in flux, it is not surprising that no specific theory has been developed on how to manipulate knowledge for

application to decision-making and problem-solving situations. However, any such theory is likely to build on existing models of data manipulation. The most fully described set of data manipulation activities is the relational model as described by (Codd, 1970). This model is based on the mathematical concepts of set theory and relational algebra. In the relational model, data is stored in the form of tables (called relations) with each column representing an attribute and each row representing the description of an entity occurrence. Within each table, the order of the rows (entities) and columns (attributes) is essentially random, although often the identifying key-attribute is placed in the initial column. Relational operators describe how the data contained in these tables is combined according to search criteria. Based on the descriptions of the relational model in (Elmasri & Navathe, 1989, pp. 145-165), data manipulation operations in the relational model can be categorized as follows:

- Operations which update data values in a relation:
  - **Insert**: include a new occurrence in a relation.
  - **Modify**: change values in an existing occurrence in a relation.
  - **Delete**: deletion of occurrences in a relation.

- Operations which filter data in a relation:
  - **Select**: a subset of the occurrences in a relation, based on some criterion.
  - **Project**: a subset of the attributes of the occurrences in a relation.

- Set theoretic operations from relational algebra:
  - **Union**: include all occurrences from either of two identically-typed relations.
  - **Intersection**: include those occurrences which can be found in both of two identically-typed relations.
  - **Difference**: include those occurrences which can be found in one, but not in the other, of two identically-typed relations.

- **Cartesian Product**: a full combination of the occurrences of two relations.
- **Join**: a combination of the occurrences of two relations based on an equality condition of a common attribute.
- **Division**: a subset of one relation, given a criterion based on another relation.

- Operations specific to the relational model:
  - **Aggregate Functions**: the sum, average, maximum, or minimum of an attribute across a relation.
  - **Recursive Closure**: the establishment of a relationship among occurrences within a single relation.

Of these operations, only the operations which update data values actually change the data stored in the relations. The others are used to select and manipulate the data at the time an inquiry is made about the data contained in the relations. Such an inquiry, called a query, specifies search-criteria for the database and results in a virtual sub-set of the database in computer-memory which is erased whenever a new inquiry is made.

The main strength of the relational model is its strong mathematical foundation which results in predictable and therefore consistent results to queries. The main shortcoming is the limited types of data this model can manipulate. Relational operations, at this time, can only be applied to text or numerical data. Moreover, virtually all relational databases currently use a fixed field-length for containing attribute-values. This means that the relational model may not be a suitable vehicle for other data types such as sounds, images, and video. For example, multimedia data cannot be directly manipulated by relational operations and often does not adhere to fixed sizes. At this time, no standard methods for the manipulation and storage of multimedia data have been developed.

Finally, a categorization of knowledge utilization was developed by Wiig. Wiig distinguishes six knowledge activities: create, build, transfer, control, use & exploit, and evaluate. (Wiig, 1992-b, p. 21) However, these activities are considered subordinate to his knowledge management theory, which is described in the following section. Moreover, Wiig considers these activities from a mostly internal and cognitive perspective and does not develop these activities as explicit knowledge manipulation processes.

2.4.3 Knowledge Management Processes

2.4.3.1 Introduction

For knowledge to be available for application purposes, it needs to be effectively administrated and controlled - in other words, managed. This section, then, examines two theories of knowledge management, both of which have been developed from the applied perspective of consultants and can be considered inductive theories. The first, by Karl Wiig is a broad and holistic theory. The second, by Tom Peters, is a cumulation of general principles based on his consulting experience.

2.4.3.2 Wiig's Knowledge Management Theory

A broad theory of knowledge management was developed by Wiig (1988, 1992-a, 1992-b). In Wiig's theory, knowledge management integrates the organization's strategic goals, economic and competitive opportunities, knowledge technologies, and operational-level knowledge. (Wiig, 1988) The objective of knowledge management, then, should be to enhance the eventual use of knowledge. Wiig's theory covers the entire process from knowledge creation and gathering, through codifying, to its eventual application to decision-making and problem-solving. The three variables Wiig (1988) recommends be considered for this endeavor are **content**, which indicates what the organization needs to

know; **location**, which indicates which organizational functions needs certain knowledge; and **process**, which indicates how to accomplish the knowledge management activities.

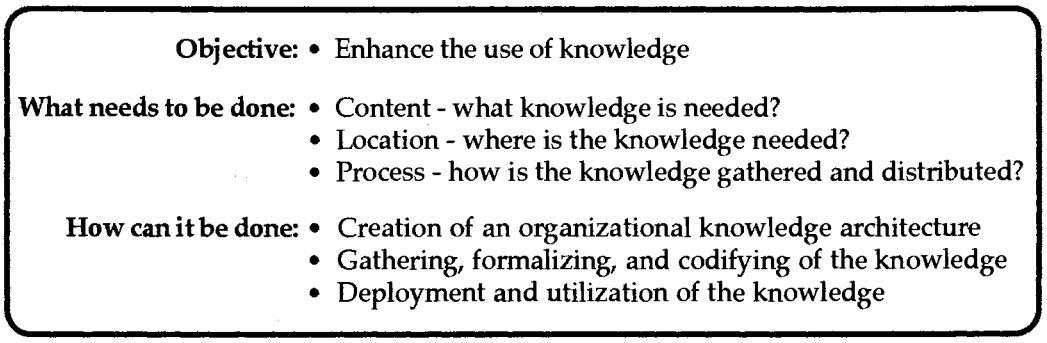


Figure 3. Summary of Karl Wiig's Knowledge Management Theory

The list of Wiig's knowledge management activities can be collapsed into three broad phases (see Figure 3). Given the objective of enhancing the use of knowledge in the organization, the first phase is the creation of an organizational knowledge architecture. (Wiig, 1990) The central question in this phase is "What do the organization's employees need to know to do their jobs well?" The organization's functional objectives then become the guiding principles for this activity. In a top-down fashion, the knowledge architecture's overall arrangement is designed before the more elemental building blocks - such as people, documents, databases, etc. - are identified. This phase also initiates the construction of what Wiig calls the Knowledge Lexicon and the Knowledge Encyclopedia. The Knowledge Lexicon is a collection of meta-information which defines and describes the organization's knowledge. The Knowledge Encyclopedia is the repository of the knowledge itself. Both repositories are filled during the subsequent phases. (Wiig, 1990)

The second knowledge management phase involves the gathering, formalizing, and codifying of the organization's knowledge. While this will eventually become a continuous activity for the organization, the initial loading of the knowledge repositories will likely be a specific project. Wiig (1990) refers to this phase as "knowledge

engineering" and notes that formalizing knowledge is easier for some knowledge categories than for others. Experience gained in knowledge engineering activities to develop expert systems could provide substantial support for this phase.

The third phase is the deployment and utilization of the knowledge. This phase focuses on distribution and control activities as knowledge and knowledge management are integrated into the organization. The knowledge contained in the Knowledge Encyclopedia can be made available to the people in the organization in a number of ways: through integrated, on-line information systems, continuing employee education, intra-organizational publications, etc. The control activities consist of maintaining and updating the knowledge architecture, the Knowledge Lexicon, and the Knowledge Encyclopedia. The control activities also include safeguarding proprietary and highly competitive knowledge. (Wiig, 1988)

The third phase becomes a continuous organizational activity. The knowledge architecture is updated when new sources of knowledge become available or when organizational knowledge needs to change as a consequence of environmental changes. The content of the knowledge repositories is added to as the organization continuously seeks out new sources of useful knowledge, such as academic research, knowledge alliances with suppliers and customers, technological innovations, etc.

Those implementing knowledge management should regard these activities from both an organizational and a technological perspective. An organizational perspective is needed because knowledge management will inevitably affect the organization's structure, processes, and functions given that the organization will likely have to adjust to use knowledge effectively. A technological perspective is needed because a variety of information technologies can be applied to the process of capturing, storing, and distributing knowledge.

2.4.3.3 Knowledge Management According to Peters

Wiig's call for an organizational perspective in knowledge management is echoed and further developed in knowledge management as it is described Tom Peters (1992). Peters' writings focus not so much on the process of knowledge management, but on the technological, physical, and organizational infrastructure necessary for knowledge management to succeed. As such, it nicely complements Wiig's theory which is more process-based. Figure 4 summarizes Peters' theory.

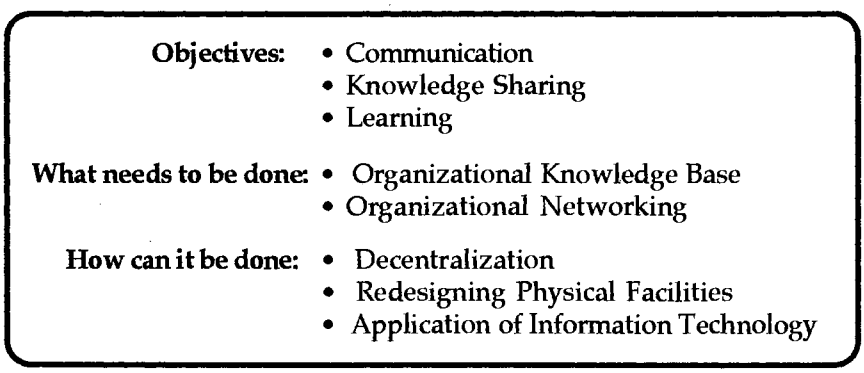


Figure 4. Summary of Tom Peters' Knowledge Management Theory

Peters views the organization as a knowledge-based society (Peters, 1992, p. 123) which - to ensure its survival - needs to engage in the continuous processes of communication and knowledge-sharing. To facilitate knowledge sharing, Peters proposes the development of an organizational knowledge base. Communication and learning are further enhanced through the use of organizational networks.

Peters reasons that because knowledge is critical to the organization and the most value-adding of its resources (Peters, 1992, p. 382; Toffler, 1990, pp. 81-88), it should be managed like a traditional resource, with the joint objectives of effectiveness of application

and efficiency of use. He proposes the development of an organizational knowledge base - which should not be just a computer system - for the provision of "internal knowledge on demand." (Peters, 1992, pp. 386-387) When using an organizational knowledge base, the employees of the organization play a dual role: they may contribute new information to the knowledge base (often from their work experiences) and they may request information from the knowledge base for application purposes. Peters stresses that the key to successful knowledge base development requires high employee involvement. For this reason, all employees should have direct access to the organization's knowledge base, the knowledge in the knowledge base should be based on what the employees feel they need to know, the knowledge should be phrased in the language of the employees, and employees contributing to the knowledge base should be encouraged to do so and rewarded when they do. (Peters, 1992, pp. 386-389)

A second way of information sharing is through the facilitation of networking. Peters considers three aspects of networking. First, an organization's employees should be involved in both formal and informal networks. Peters calls this "the informating of all employees." (Peters, 1992, p. 121) Second, networking should be supported both by human contact and telecommunications. (Peters, 1992, p. 443) Third, networking should not only occur within the organization but also between the organization and its environment. Peters refers to this as "the insiderization of outsiders." (Peters, 1992, p. 121)

Finally, Peters describes three ways to bring about effective knowledge management in the organization. First is the decentralization of the organization and changes in organizational roles. By taking technological experts and administrative specialists out of a central location and placing them into work teams and project groups, expertise is more readily accessible to the teams while the experts can directly adapt their expertise to its particular purpose. (Peters, 1992, p. 443) Second is the redesign of the

physical facilities of the organization. Given that physical proximity encourages teamwork and knowledge exchange (Peters, 1992, p. 413), the organization's facilities need to be flexible to allow people who work together to be working near each other, resulting in "effective" buildings which change as teams form and disband. (Peters, 1992, p. 415) Third is the application of information technology. The well thought-out application of information technology enables communication and learning by providing timely access to people and to relevant knowledge. However, the casual application of computers "can provide a false sense of security." (Peters, 1992, p. 390) The most promising application of technology, according to Peters, is computer augmented collaboration which allows people to cooperate in real-time on a single plan, design, or document. (Peters, 1992, pp. 434-435)

An important shortcoming of Peters' writings on knowledge management is that he never spells out a clear and cohesive theory. Although he advocates that the organization have a clear plan for managing its knowledge resources, his own publication on the subject (Peters, 1992) lacks a clear guide to do so. This is particularly evident when compared to Wiig's theory (Wiig, 1988), which lays out a clear sequence of activities, events, and requirements.

2.5 Knowledge Organization

2.5.1 The Need for Knowledge Organization Structures

> "Trying to wade through information without a sense of its structure is like going to the Library of Congress and aimlessly combing the shelves for a particular book. Once you have a sense of how the whole is organized, you will reduce the frustration of searching for a needle in a haystack. Even if the needle is all that you need, it will behoove you to know how the hay is

organized." (Wurman, 1989, p. 59.)

The theoretical and practical aspects of this project meet in the design of a knowledge organization structure and the development of a prototype into which knowledge can be loaded and from which it can be extracted. Two factors distinguish the prototype's database from more traditional database types. First, the materials stored in it are knowledge rather than data and are consequently not easily placed into a record and field type storage. Second, the exact nature or content of the knowledge is unknown prior to their placement in the structure. Consequently, traditional database structuring techniques such as data modeling and normalization cannot be used. The eventual application, then, provides the opportunity to develop a generally applicable method for organizing pieces of knowledge.

The need for structure in information collections is not new: for centuries libraries have systematically organized large amounts of information. However, recent developments in computer databases have provided access to vast quantities of information which can be accessed on-line. The nature of the on-line information and the methods of its access have required the development of new ways of organizing the information. The development of database models such as the hierarchical and the relational architecture were important developments in this respect. (Navathe, 1992) However, on-line organizational and public databases have been growing, both in quantity of data and variety of information-types, and new methods of access will soon be needed. (Henriksen, 1991)

At this time, the development of new, effective knowledge organization frameworks is an important aspect of information retrieval. (Henriksen, 1991; Parsaye, Chignell, Khoshafian, & Wong, 1989; Ritchie, 1989) As databases have grown, researchers have realized that the random order of data, as implied by the relational model, may not always permit an optimal access strategy. Moreover, they found that keyword

searches alone will not always suffice, but that indexing and knowledge frameworks are needed. The need for at least a rudimentary form of indexing can be inferred from the model for information retrieval by Salton & McGill (Parsaye, Chignell, Khoshafian, & Wong, 1989, p. 302) as shown in figure 5, which directly links the search for information to the structure brought to the information collection.

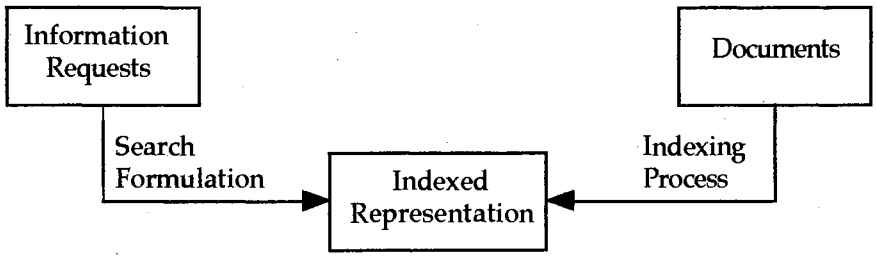


Figure 5. Salton & McGill's Information Retrieval Model

A strong call for the structuring of knowledge is also made by (Henriksen, 1991) in his article on information structures (tectonics), where he states that "free text searching ... is an invaluable aid in groping your way through large, existing, unstructured corpuses, but nothing more. Never fall for the temptation to believe that free text searching can replace information tectonics!"

A potential reason for Henriksen's criticism of the use of free text searching in an unstructured knowledge base is its potential for a needle-in-the-haystack search as described by Wurman at the start of this section. For a free text search, the actual knowledge in a knowledge base, as well as its structure, remain hidden from the user and cannot be used to aid in the search. Applying a free text search, then, relies on the notion that the words used to describe the knowledge are identical to those used to search for it, and this may not always be true. A free text search would not find the knowledge a user needs when it does not include the exact search words used by the person performing the search. For example, a person searching by keyword for "waiting line theory" would not

be able to find this information if it were solely indexed by its other name, "queuing theory." Moreover, these search words could very well appear in other pieces of knowledge the person does not need, but which would be retrieved anyway. For example, a search by keyword for "multimedia" would not only retrieve information on the use of sounds, images, and video on computer-screens; it would also retrieve information on the advertising strategy which employs multiple media (such as newspapers, television, sponsoring, etc.) which is also commonly referred to as "multimedia." It would be more beneficial if the person doing the search would be guided through the knowledge base using an implied knowledge structure. In this way, the person could choose a search path through the knowledge base on the basis of what is actually contained in the knowledge base rather than on similarities of word-choice.

The effect of having an explicit knowledge structure has not only a positive effect on search effectiveness - that is, the search results in finding the knowledge you intended to find- but also on search efficiency - that is, it reduces the time needed to find the knowledge. When using an implied knowledge structure, knowledge base searching can become more efficient, given that the person doing the searching is familiar with the knowledge structure applied.

The application of a knowledge structure also has some implications for knowledge base management. Management of the knowledge base is improved by using a structure, because it is possible to identify how much of the structure has been filled in by the existing knowledge and what gaps in the knowledge still exist. For instance, a free text search on a large collection of unordered names and addresses will eventually provide a user with the address for a given name. However, when the addresses have been ordered alphabetically, as in a phone-book, the search becomes much faster, given that the user is familiar with the alphabet. From a knowledge management point of view, the use of the alphabetical structure would allow one to find out that no names and addresses are in the

knowledge collection for names starting with the letters Q through T, something which would be virtually impossible to determine from a collection of unordered names.

2.5.2 Content- and Purpose-Based Knowledge Structures

2.5.2.1 Introduction

Two basic philosophies of knowledge organization have been articulated: organization by content as advocated by Ted Nelson's original intention for hypertext, and organization by purpose, best described by Petter Henriksen's aforementioned concept of information tectonics. These philosophies both oppose and complement each other and are described in more detail below.

2.5.2.2 Content-Based Knowledge Structures

> "The structures of ideas are not sequential. They tie together every which-way. And when we write, we are always trying to tie things together in non-sequential ways." (Nelson, 1974, p. 29)

The content-based philosophy of knowledge organization develops the structure of the knowledge base from its content, and is based on Ted Nelson's assertion that "everything is deeply intertwingled." (Nelson, 1974, p. 31) This philosophy has become the basis of Nelson's concept of hypertext.

The hypertext database architecture, as developed by Ted Nelson, was initially described as "non-sequential writing." (Nelson, 1974, p. 29) More to the point, hypertext provides a reader or writer with "an opportunity to jump away from some point in the text" (Nelson, 1982) to another, related piece of text, and and arranges ideas "in a way that

allows an individual idea to be referenced elsewhere." (Conklin, 1987) Hypertext, then, interconnects pieces of knowledge, generally referred to as nodes, using so-called links.

Nelson imagined a single hypertext application which "would consist of materials brought together from all over," ranging from "a hypertext consisting of 'everything' written about a subject, or vaguely relevant to it," (Nelson, 1974, p. 32) to a grand hypertext, a "universal archive" which would literally contain every piece of human knowledge stored in digital form, a "common repository for the writings of humankind." (Barlow, 1991) Nelson's Xanadu project links documents according to inter-connections and commonalities in their content or ideas. Although Nelson's notion of hypertext as a storehouse of all the world's information was - and still is - considered rather utopian, more limited hypertext applications have been used in a variety of areas.

2.5.2.3 Purpose-Based Knowledge Structures

> "The more true to nature an information model is, the better it functions for the user." (Henriksen, 1991)

The purpose-based philosophy of knowledge organization develops the structure of the knowledge base from its intended use. It was developed by Petter Henriksen who named it "information tectonics," thereby directly relating it to architectural and construction activities. Henriksen (1991) does not presume that a single knowledge framework will be able to capture and provide access to all available knowledge. Rather, given that information derives its value from its use, information tectonics is described as "the organizing of information in structures adapted to the needs of the user." (Henriksen, 1991) Henriksen realized that a knowledge structure should not solely (or even chiefly) be determined by the content of the knowledge, but rather by its intended use. The resulting meta-structure would then allow a user to effectively and efficiently access the knowledge.

Consequently, a single collection of knowledge could be organized in a variety of ways, each one differing on the basis of its intended use. In addition, a single knowledge structure could possibly be used to organize knowledge from a variety of disciplines given a single purpose of use. Given Henriksen's approach, the development of a single, all-encompassing knowledge structure may be unrealistic, if not impossible.

Until now, little research has been conducted regarding the potential of these two philosophies to shape knowledge organizations. Many databases have been organized either by their content alone (as realized by the procedure of data normalization in relational database design) or by their purpose alone (which is efficient access to data and has become a major technical consideration of database design), but this may have been a limitation posed by available technologies. Current hypertext applications, however limited compared to Nelson's original vision, allow for the application of both content- and purpose-based organization. The knowledge organization structure which will be developed for this project's prototype will incorporate aspects from both the content-based and purpose-based philosophies of knowledge organization.

2.5.3 Structure Types

> "Hierarchical and sequential structures ... are usually forced and artificial. Intertwingularity is not generally acknowledged - people keep pretending they can make things hierarchical, categorizable and sequential when they can't." (Nelson, 1974, p. 31)

While it would appear that a seemingly unlimited variety of knowledge structures has been developed over time, only a small number of primitive structure types underlie this variety. Brockmann, Horton, & Brock (1989) identified four basic structure types, as shown in figure 6. Any knowledge structure, then, could be classified as one or a

combination of several of these structures. Consequently, the knowledge organization structure to be developed for this project will also be based on these four structure types.

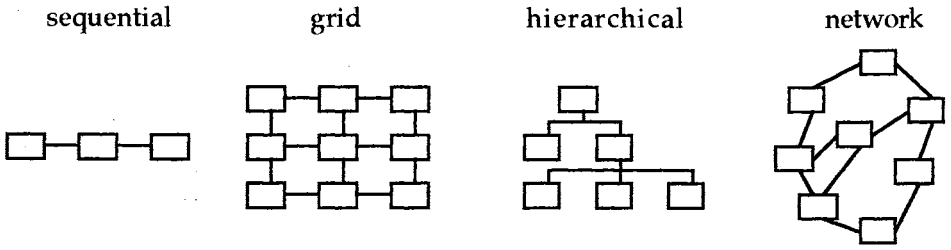


Figure 6. Primitive Structure Types

- **Sequential**: this structure is simplest to understand. Early storage methods - sequential files - organized data in this manner. While newer database architectures, such as the hypertext architecture, can be used for the sequential structuring of knowledge, doing so takes little advantage of the more advanced knowledge organization abilities of these architectures. A disadvantage of a linear organization of knowledge is that it severely limits the use of organizational cues when organizing or consulting a database.

- **Grid**: this two-dimensional structure allows for the layout of knowledge along two axes. Breadth and depth of a topic can easily be conceived when knowledge nodes are organized in a grid. In addition, it is not too difficult to envision a three-dimensional structure as a stack of interconnected grids. While the relational database architecture (described in section 2.4.2) is in essence an example of the implementation of sequential data structures, the relational operators allow for the construction of grid-like data structures.

- **Hierarchical**: this is a common method of organization, and for a reason: according to Horn, people often organize information in hierarchical form,

regardless of how the information was originally presented to them. (Horn, 1989, p. 51) A hierarchical knowledge organization structure exploits human information organization preferences.

- **Network**: while a network - which Brockmann, Horton, & Brock (1989) call a "web" - is the most expressive knowledge organization structure, it is also the structure in which people most easily lose their bearings. When users traverse a network structure, clear orientation markers are needed for the users to be able to obtain the information they want. Simplicity, then, is a virtue when it comes to network structures.

The following section provides a survey of a variety of existing and proposed knowledge structures. Each of these structures can be viewed as the application of one or more of these four basic structure types.

2.5.4 A Survey of Existing Knowledge Structures

2.5.4.1 Introduction

The following section presents models for organizing knowledge and their advantages and disadvantages. Most of these models appear to subscribe to one of the two previously outlined theories of knowledge organization, in which the structure applied to the knowledge is determined either by the content of the knowledge or the purpose to which it is to be put.

Besides the content/purpose orientation, the following descriptions also indicate which of the primitive structure types (sequence, grid, hierarchy, or network) these knowledge structures are composed of. A final way to compare and contrast them is

through the use of a continuous example of knowledge organization using the structures (except for the final two structures, which already have been supplied a content). This example describes the development of an information system for an organization's human resources functions. Both the aspects of the system development process and the content of the human resources area will be examined in these examples.

2.5.4.2 Wurman's Organization of Knowledge

According to Wurman (1989, pp. 59-61), all information can be organized according to the following five methods. Sometimes several of these methods can be combined in a hierarchical manner.

- **Category**: this method of organization lends itself well to organizing items of similar importance.
- **Time**: this method works well for events that happen over fixed durations and for the observation of changes over time.
- **Location**: this method allows for the examination and comparison of information from different sources and locales.
- **Alphabet**: this method lends itself well to organizing large bodies of information, especially when the other four methods of organization are less meaningful.
- **Continuum**: this method allows organization of items by magnitude, order of importance, etc., and allows for the assignment of value or weight to the information.

The key decision when applying Wurman's five methods is the choice of which particular method to use for structuring a body of knowledge. According to Wurman "your choice will be determined by the story you want to tell. Each way will permit a different understanding of the information." (Wurman, 1989, p. 59) In other words, the

same body of knowledge can be organized in different ways, depending on the purpose of conveying the knowledge. Wurman's method, then, combines both aspects of purpose (the selection of the appropriate method) and content (the organizing of knowledge within each method).

Each of the five knowledge organization methods can be examined for which primitive structure types they contain:

- **Category**: categorization of topics - especially when several levels of categorization are involved - is a hierarchical structure.
- **Time**: the observation of developments over time is a sequential structure.
- **Location**: two structure types apply to location. A hierarchical structure can be used to focus in on a location (e.g. continent, country, province, city, street, etc.). A network structure can be used to demonstrate the relative position of different locations as on a map.
- **Alphabet**: alphabetical organization is essentially sequential: all pieces of knowledge can be laid out as a single sequence in alphabetical order.
- **Continuum**: similar to alphabetical organization, pieces of knowledge organized by continuum can be considered sequentially structured.

Considering the example of information system development for an organization's human resources (HR) activities, the following are ways in which Wurman's knowledge organization methods can be used to structure human resources materials.

- **Category**: HR activities can be organized in categories, such as hiring, training, compensation & benefits, etc..
- **Time**: HR processes can be considered over time. For example, to fill a position, the time-ordered sequence of events involves determining the vacancy, advertising

the vacancy, process the applications, interviewing selected applicants, determining the most preferable applicant, and hiring this applicant.

- **Location**: HR can organize its employee files by departments, locations, or a combination of both.
- **Alphabet**: a listing of an organization's employees organized alphabetically by last name.
- **Continuum**: HR can examine the make-up of the organization's workforce as listed by age (from young to old) or in length of tenure with the organization (in years).

As can be inferred from the above example, Wurman's methods of organization are very general, and perhaps too much so. While, according to Wurman, the five methods are capable of including all possible types of knowledge, they are likely to be too general to be of much use in knowledge structure development. Consequently, consistent and appropriate application cannot be guaranteed. This is a major obstacle when a knowledge structure is to be used widely across disciplines.

An important implication of these "five ultimate hatracks," as Wurman (1989, p. 59) calls them, is that they seem to imply that no single method will be able to effectively organize all available knowledge.

2.5.4.3 Issue-Based Information Systems (IBIS)

IBIS is a purpose-based knowledge organization model which has been used in the hypertext field for structuring debates (Conklin & Begeman, 1989). Information coming out of a debate is fragmented into the hierarchical structure illustrated in figure 7.

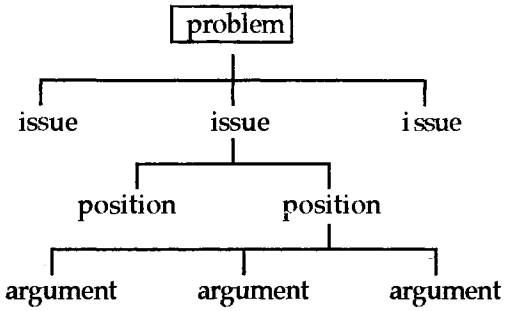


Figure 7. IBIS Structure

The contents of the different levels can be briefly described as follows:

- **Problem** - the start of the debate and topic of discussion.
- **Issue** - aspects of the problem which are often interrelated.
- **Position** - positions taken by people on each of the issues.
- **Argument** - arguments supporting or opposing the various positions.

The IBIS model is clearly a hierarchical structure. Figure 8, then, shows an example of the debate for choosing a system development approach for a human resources information system.

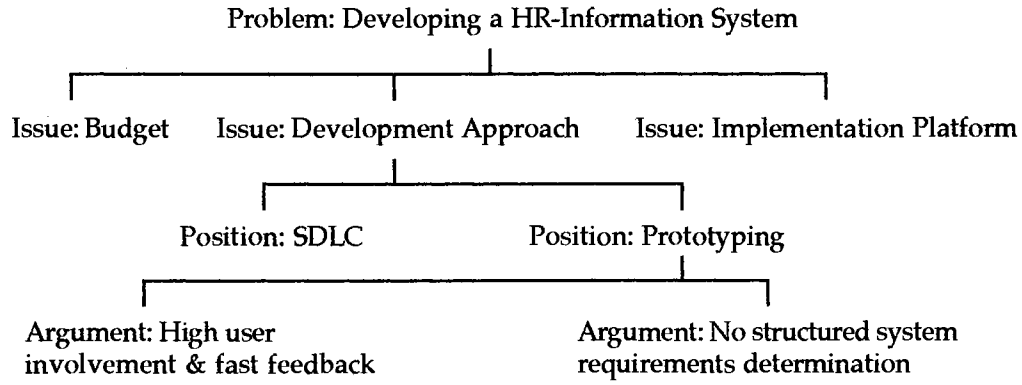


Figure 8. Example of IBIS structure

A few issues must be considered, regarding this model. First, how obvious would this structure be to a user of the structure? It is likely to need some accompanying explanation or user learning. Second, the rather fixed structure of this model may become too limiting. If a knowledge structure is to include materials from a variety of disciplines, this model may not be appropriate. The strength of IBIS appears to be the modeling of rhetorical, conceptual, or theoretical material. However, it appears to have only limited capacity for dealing with procedural, skill-based, mechanic, or applied knowledge.

2.5.4.4 Breadth and Depth of a Topic

Brockmann, Horton, & Brock (1989) describe the two-dimensional or orthogonal knowledge structure as a general and intuitively obvious method of organizing knowledge. The linear sequence of topics serves as a table of contents for the information below it. Figure 9 illustrates this concept.

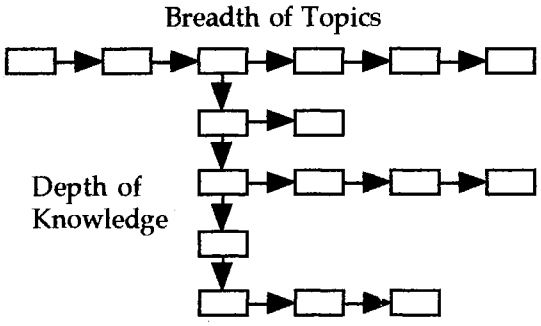


Figure 9. Breadth & Depth Architecture

As intuitively obvious as it is, this picture is not complete. It does not state specifically how the knowledge should be organized along the two dimensions. The following are three suggestions for organizing the knowledge in depth.

Organization by Proficiency Level

The first suggestion for organizing knowledge along a depth-dimension comes from Wiig (1992-a) and is a method which combines content- and purpose-based aspects of knowledge organization. The content-based aspect springs from the decomposition of knowledge based on the complexity of its content, as this is often closely related to proficiency level. The purpose-based aspect springs from the decomposition of knowledge for the purpose of training differing sets of students.

Wiig recognizes 8 successive levels of proficiency and argues that for each area of expertise, a person's proficiency level - called a knowledge profile - can be assessed. (Wiig, 1992-a, pp. 136-137) The concentric circles in figure 10 represent increasing levels of proficiency within specific areas of expertise. When required levels of proficiency for a task (indicated by a solid line), as well as the actual proficiency of an employee (indicated by a dashed line), are known, knowledge deficiencies of a person can be specifically addressed. (This is visualized as the gray area in the knowledge profile.) Consequently, learning efforts can be specifically targeted to specific areas of expertise.

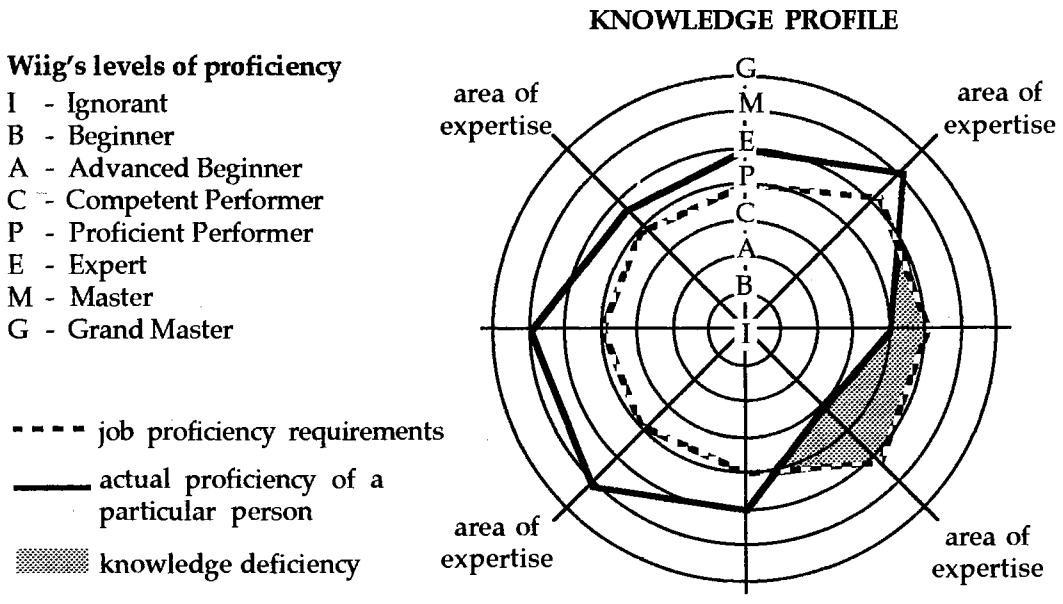


Figure 10. Overview of Wiig's Proficiency Levels

Wiig describes the 8 levels of proficiency as follows:

- **Ignorant** - totally unaware of the area.
- **Beginner** - vaguely aware, with little and arbitrary understanding.
- **Advanced Beginner** - Informed but relatively incompetent, cannot work alone.
- **Competent Performer** - Beginning to develop an understanding, can do some work alone.
- **Proficient Performer** - Competent and broadly skilled.
- **Expert** - Highly proficient in a particular area.
- **Master** - Highly expert in many areas and broadly knowledgeable.
- **Grand Master** - Both knowledgeable and wise in all areas of the domain.

The primitive structure type underlying this method is the two-dimensional grid. One axis of the grid is composed of topics or areas of expertise, the other axis is the continuum which ranges from Ignorant to Grand Master. Pieces of knowledge for each topic can be placed at their appropriate positions given the two dimensions. Knowledge for each particular topic can subsequently be extracted from this knowledge structure at the proficiency level appropriate to both the student and the task requirements. A learning process, then, could specifically target the gray area of knowledge deficiency in figure 10.

An example of an application environment for the proficiency-level based organization of knowledge would be an organization's human resources activities, especially in the areas of evaluation and training. Consequently, system development effort for a human resources information system could adopt this model to organize human resources data.

The chief drawback of this approach is in the assessment of the level of expertise, both of the employee/student and of the materials to be placed in the structure. No single consensus method of assessing expertise across a variety of fields has been developed, and Wiig's descriptions of are neither unambiguously precise, nor are they an HR standard. Consequently, no determinate method exists for assigning materials of a particular proficiency level to an employee/student. In addition, the evaluation of learning materials as it relates to a particular proficiency level is an ambiguous exercise. There is as of yet no empirical evidence which demonstrates that this eight-level framework can be successfully applied or that all eight levels are necessary.

An final drawback of this method is that it assumes that all knowledge materials can be organized by proficiency level. Some knowledge may apply to several or to all proficiency levels. What would therefore appear to be needed in this method is a "general" category in order to classify that knowledge which is not specifically related to any particular proficiency level.

Organization by Level of Detail

The second, content-based method for knowledge organization along a depth-dimension is by dividing it up into increasing detail. (Wiig, 1992-a, p. 140) For any knowledge domain, 6 levels of increased subdivision are possible, as shown in figure 11.

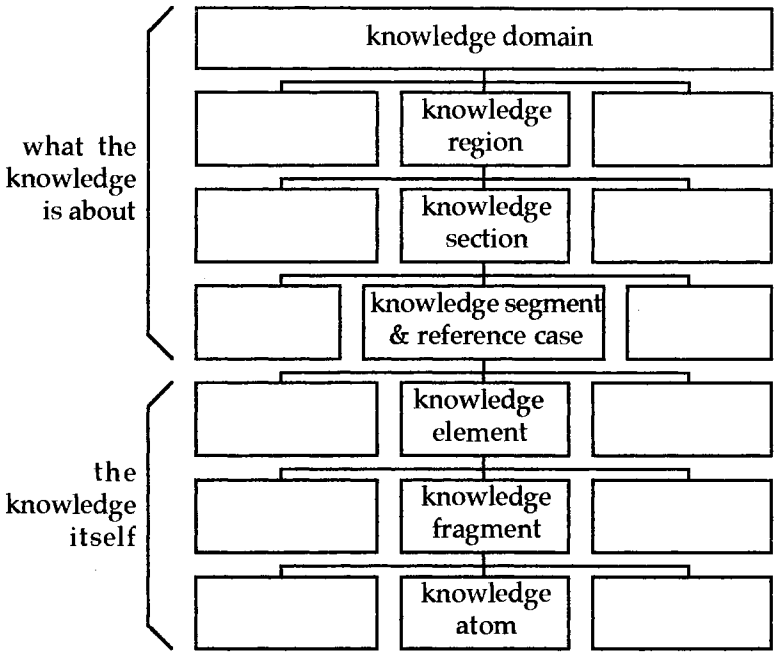


Figure 11. Overview of Wiig's Levels of Detail

Wiig defines these levels as follows:

- **Knowledge Domain** - General knowledge area.
- **Knowledge Region** - General area of specialties.
- **Knowledge Section** - Particular area of expertise.
- **Knowledge Segment** - Specific task within a particular expertise.

  Reference Case - Relatively complete and detailed case history.
- **Knowledge Element** - The particulars of strategies, procedures, or concepts.
- **Knowledge Fragment** - Aggregated assemblies of specific knowledge objects.
- **Knowledge Atom** - Single facts.

The primitive structure type underlying this method is clearly the hierarchy. When combined with the breadth-and-depth approach to knowledge organization, the sequence-structure of knowledge domains connects the hierarchical structures of increasing detail below it. The following, then, is an example of the six levels of a knowledge domain given

the development of a human resources information system.

- **Knowledge Domain** - Corporate information systems.
- **Knowledge Region** - Management of information systems.
- **Knowledge Section** - Systems analysis and design.
- **Knowledge Segment** - Development of a human resources management information system.

  Reference Case - Details of human resources in the organization.
- **Knowledge Element** - Prototyping approach to system development.
- **Knowledge Fragment** - Inputs, processes, and outputs that exist in the human resources information system.
- **Knowledge Atom** - Employee skill requirements and available skill levels within the organization.

The consequences of this approach for the depth-dimension of the two-dimensional knowledge organization structure are as follows: the depth-dimension becomes a hierarchy of the knowledge of the topic. Knowledge for each topic can then be automatically extracted from the knowledge structure according to the topic and level of detail. When a particular level of knowledge is extracted, it is possible to include the knowledge placed hierarchically below it.

This approach is not without problems. One drawback is the lack of context. When a particular low-level piece of knowledge is selected for examination, the reader will not see any of the related pieces at the same or at higher levels. For example, a person examining the prototyping approach to system development in the above example will not see alternative strategies at the Knowledge Element level, or the description of the human resources department at the higher Reference Case level. This, then, may take the knowledge out of context, thereby prohibiting full understanding of the knowledge.

On the other hand, overkill could become a drawback as well. The information below the chosen piece of knowledge may provide too much detail for the reader. For example, a person interested in an example of a recent information systems development in the organization would be satisfied with the description of the Knowledge Element level, but would have little use for the details of the inputs, processes, and outputs which are provided at the Knowledge Fragment level. The problem, then, becomes just which nodes to select, given a person's knowledge needs.

Finally, Wiig's separation of the knowledge itself from its meta-knowledge (knowledge about the knowledge) may not be beneficial to the integration of concepts or to the comprehension of the student.

Organization by Precedence of Knowledge

This third method for organizing knowledge along a depth-dimension is by precedence. Much learning is cumulative: more advanced learning needs to be preceded by the learning of basic concepts. (Gagne, 1962) Therefore, a method which organizes the content of knowledge for the purpose of learning - and which thus combines aspects of purpose and content - could organize materials based on precedence or prerequisite knowledge. When using a structure as shown in figure 12, the elementary aspects of a topic would be placed near the topic header or root-level of the structure. More advanced aspects - the ones that build on the elementary aspects - would be further removed from the root level. Connecting lines mark the precedence relationships.

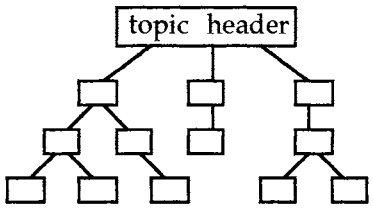


Figure 12. Knowledge Precedence Structure

This method of organizing knowledge looks at first like a hierarchical structure type. However, when two pieces of knowledge are required as the precedent for a third piece of knowledge, this structure becomes a network. In the breadth-and-depth approach to knowledge organization, the sequence-structure of knowledge areas ties together precedent hierarchies of sub-areas. For example, figure 13 shows a simple example of how different topics within the area of system development can form a precedence network.

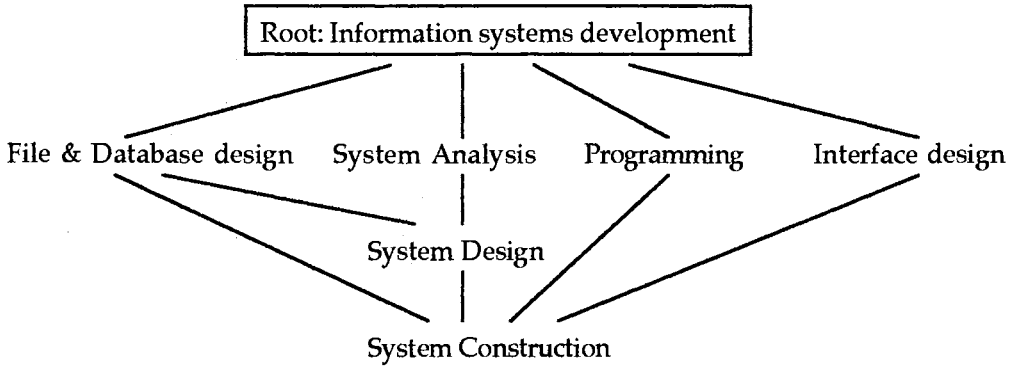


Figure 13. Example of the Knowledge Precedence Structure

The consequences of this approach for the depth-dimension of the two-dimensional knowledge organization structure are as follows: whenever a particular piece of knowledge is selected for learning purposes, the resulting learning sequence will need to include precedent pieces of knowledge. For example, a person who wants to know how to construct a human resources information system would need to know its system design, a

programming language, a file or database design approach, and an interface design approach. Consequently, a person will be able to better comprehend the knowledge because all knowledge prerequisites will have been provided.

This approach may not always be appropriate. When a person is already knowledgeable about the basic concepts, the precedent pieces of knowledge may not be needed. Moreover, it is not difficult to imagine areas of expertise where a precedence hierarchy is not required or where such a hierarchy would become a hopelessly complicated network. For instance, a piece of knowledge low in the hierarchy could have as precedent pieces some pieces from various subtrees. (Such as in the example above.) How will these pieces be presented? What order should they be in? How much of it would be appropriate for the learning needs of the student?

Dewey Decimal Classification

As noted before, libraries have long dealt with the organization of vast quantities of knowledge from a large number of disciplines. At this time, three major methods are being used in U.S. libraries to organize, represent, and arrange library materials: the Library of Congress Subject Headings, the Library of Congress Classification, and the Dewey Decimal Classification. (Chan, 1990) Of these three, the Dewey Decimal Classification (DDC) is the most widely used. (Comaromi, et al., 1989)

Despite its highly particular purpose, DDC is a essentially a content-based knowledge organization method. It allows libraries to organize their collections according to a tree-based hierarchical structure based on ten main classes (often referred to as disciplines), each of which are further subdivided into ten divisions, which are subdivided into ten sections. Below the sections, further subdivisions are allowed. At the lowest level, works are alphabetized by author. The ten main classes of DDC are shown in figure 14.

000	Generalities
100	Philosophy, parapsychology and occultism, psychology
200	Religion
300	Social sciences
400	Language
500	Natural sciences and mathematics
600	Technology (Applied sciences)
700	The arts Fine and decorative arts
800	Literature (Belles-lettres) and rhetoric
900	Geography, history, and auxiliary disciplines

Based on: Comaromi, et al. (1989), pp. xxviii.

Figure 14. Main Classes of the Dewey Decimal Classification

DDC keeps its levels in groups of threes, in between which it places decimal points or spaces. Figure 15 shows an example of the DDC hierarchy, based on (Comaromi, et al., 1989), for the topic of information management in business.

Main Class:	600	Technology (Applied Sciences)
Division:	650	Management and Auxiliary Services
Section:	658	General Management
	658.4	Executive Management
	658.40	Specific Executive Management Activities
	658.403	Decision Making and Information Management
	658.403 8	Information Management

Figure 15. Example of DDC Hierarchy

DDC's main disciplines are sufficiently broad to classify any piece of knowledge. However, this method will often cause particular subjects to be broken up among various disciplines, causing it to become fragmented across the hierarchy. This has given rise to DDC's Relative Index, which lists subjects alphabetically with all related materials arranged alphabetically under them. (Comaromi, et al., 1989) Figure 16, for example, shows the entry in the relative index for the topic of information management.

Information Management	
Executive Management	658.403 8
Office Services	651
Production Management	658.503 6
Public Administration	350.007 22
Central Governments	351.007 22
Local Governments	352.000 472 2

Figure 16. Example of Relative Index

By combining the subject hierarchy and the relative index, DDC can be viewed as a two-dimensional grid structure, as shown in figure 17. A specific aspect of a particular topic can then be pinpointed at the intersection of a subject and a discipline heading.

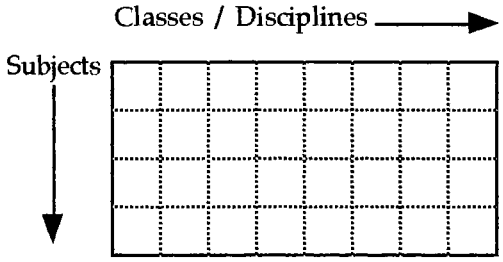


Figure 17. The DDC grid

While thorough, this approach may in fact be too detailed to be used as a general knowledge structure. In addition there are two problems when organizing knowledge according to this method: first, classifying knowledge according to DDC is a precise, difficult, and sometimes ambiguous task and may therefore be difficult to accomplish consistently. Second, a particular piece of knowledge could be broad enough to fit into several places in the classification. However, the hierarchical nature of DDC is, according to Horn (1989), an natural and intuitively obvious one.

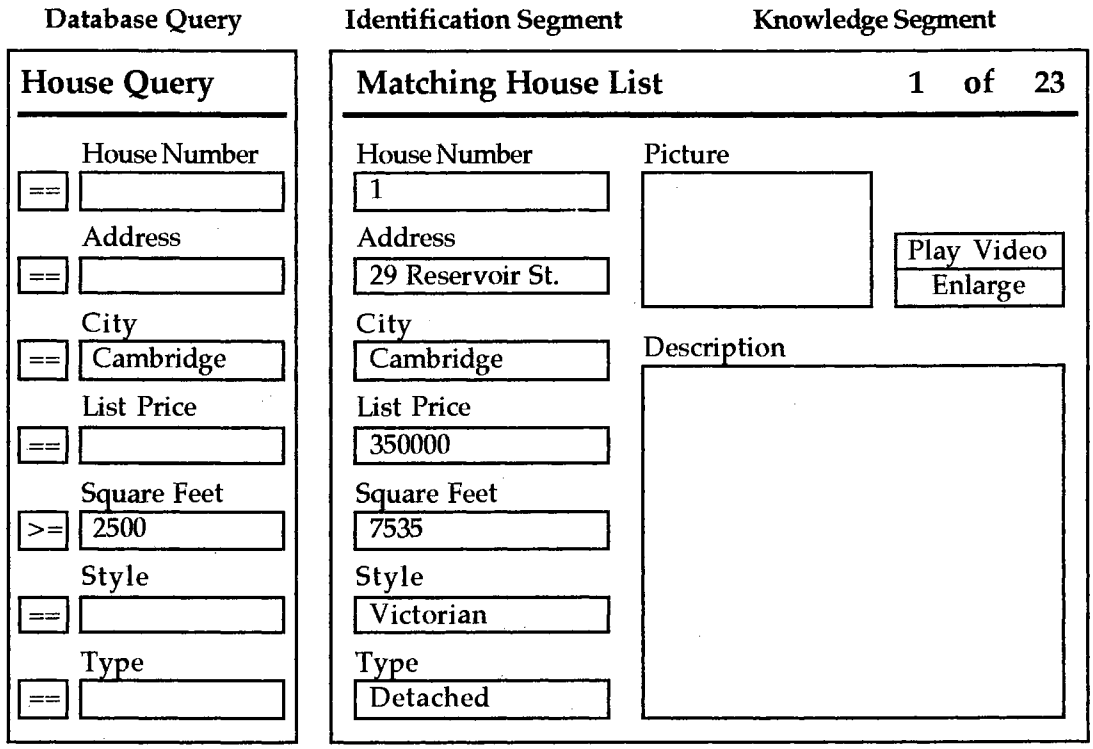
A greater drawback becomes evident when DDC is applied. While this framework has proven to be valuable when organizing library materials, searching for knowledge often

does not involve a structural search. Instead, most libraries provide for a keyword search in their catalogs. Especially with on-line library catalogs, keyword searching has become the primary mode of finding materials, using either DDC descriptive terms or the materials' titles for access. Consequently, for retrieval purposes, DDC could be viewed as more of a knowledge description technique rather than a knowledge organization structure.

2.5.4.5 Frame-Based Organization

(Hodges & Sasnett, 1993) describe a content-based multimedia database storage model reminiscent of the frame-based organization of knowledge in expert systems. In this model, each multimedia record contains several fields which may be searched with either system-specified or user-specified values. In the example cited by (Hodges & Sasnett, 1993), a multimedia real-estate database can be queried given a set of provided attributes, after which the resulting set of matching records can be examined by the user. (See figure 18.)

For this method, each multimedia node consists of an Identification Segment and a Knowledge Segment. The Identification Segment contains attributes which uniquely and descriptively identify the node. The Knowledge Segment contains the actual multimedia information and enhances the textual and numerical information of the record's Identification Segment. This method is most closely related to traditional database search approaches and, given Henriksen's aforementioned objections to text searches, does not specifically constitute a knowledge organization method, but rather a search structure.



Based on: Hodges & Sasnett (1993), pp.17-18.

Figure 18. Example Node Architecture for Frame-Based Method

The attributes of the Identification Segment need not be filled in arbitrarily. Rather, a list of permitted identification terms could be drawn up which can be used to fill in the attributes. These terms are then defined so that they can be used consistently. When a multimedia database is to accommodate knowledge from a variety of disciplines, the list of possible attributes and their related identification terms will likely expand, even under the control of a database administrator or, in the case of the prototype, the knowledge base administrator.

While the chief advantage of this method is that it is likely to accommodate nodes from any discipline, its lacks an implied and explicit structure. The primitive structure type which underlies this method is - at least nominally - sequential, in that the multimedia-nodes can be viewed in a sequence based on the search criterion. Such lack of explicit

structure, however, can easily lead to "pollution" of the knowledge base and poor node content development. However, this method could be used in combination with any of the other proposed frameworks to accommodate frame-based searching of the database.

2.5.4.6 Summary

Table I summarizes the findings of the above knowledge structures. As is clear from this table, most methods structure knowledge collections based on their content. Only Wurman's 5 methods, IBIS, Proficiency Levels, and Precedence include the intended use or purpose of the knowledge as part of their structure. However, given Henriksen's arguments, purpose would have to be considered when trying to structure a knowledge base for practical use. Also apparent is the frequent use of the hierarchy structure type to organize materials. The intuitive nature of the hierarchical structure has already been pointed out (see section 2.5.3), and it is evident that knowledge structure designers have taken this to heart.

Structure	Structure Basis	Structure Primitive	Essence of Structure
General Methods (Wurman)	Content & Purpose		Five general "hatracks" for information, which may be combined.
• Category		Hierarchy	
• Time		Sequence	
• Location		Hierarchy / Network	
• Alphabet		Sequence	
• Continuum		Sequence	
IBIS (Conklin & Begeman)	Purpose	Hierarchy	Decomposition of a topic based on semantic relation to higher level.
Proficiency (Wiig)	Content & Purpose	Grid	Division of knowledge based on student's proficiency level.
Increasing Detail (Wiig)	Content	Hierarchy	Decomposition of knowledge into increasing levels of detail.
Precedence	Content & Purpose	Hierarchy or Network	Organization of knowledge based on prerequisite knowledge.
Dewey Decimal Classification	Content	Hierarchy or Grid	Decomposition of knowledge by discipline and subject.
Frame-Based (Hodges & Sasnett)	Content	Sequence	Keyword search method.

Table I. Summary of Knowledge Structuring Methods

CHAPTER III

TOWARD A PROPOSED THEORY OF KNOWLEDGE, KNOWLEDGE UTILIZATION, KNOWLEDGE MANAGEMENT, AND KNOWLEDGE ORGANIZATION

3.1 Introduction

Based on the knowledge-related literature reviewed in chapter 2, this chapter describes a a proposed theory of what constitutes knowledge, its utilization, its management, and its organization. The sections in this chapter contain the following topics:

- Section 3.2 reviews the background on theory development and validation.
- Section 3.3 provides an overview of the proposed theory, its major components and its propositions.
- Section 3.4 defines and describes knowledge.
- Section 3.5 describes knowledge utilization.
- Section 3.6 describes knowledge management.
- Section 3.7 describes knowledge organization and the design of a general knowledge organization structure.

The theory on knowledge organization and the general knowledge organization structure described in section 3.7 will become the basis of the application prototype which was outlined in section 1.2. The development and implementation of this application prototype is described in chapter 4.

3.2 Theory Development and Validation

3.2.1 Introduction

This chapter contains a proposed theory of knowledge, its utilization, its management, and its organization. This theory integrates the insights gained from previous theories and practical experience into a single whole. In addition, this theory can serve as the basis for future research in the field of knowledge.

Before the actual proposed theory is put forth, it is appropriate to briefly review what constitutes a theory, the purpose of theory, the theory development process, and the theory validation process. The following sections contain this synopsis.

3.2.2 Theory Defined

Bacharach (1989) describes theory as "a statement of relations among concepts within a set of boundary assumptions and constraints. It is no more than a linguistic device used to organize a complex world." A similar description comes from Dubin (1976), who describes theory as "the attempt of man to model some aspect of the empirical world." Patterson (1980) states that a theory organizes and interprets the facts and knowledge of a particular field and states these in the form of laws or principles.

A list of the components of a formal theory was developed by Dubin (1976). This list starts out with four inductive components of theory: **units** or variables constitute the subject matter of the theory; the **laws of interaction** specify the relationships among the theory's units; **boundaries** specify the limitations within which the theory is expected to be valid; and **system states** or conditions specify how the units interact within the boundaries, at times given specific boundary conditions. Dubin's list concludes with three deductive

components of theory: **propositions** are logical deductions expected to be true within the theory; **empirical indicators** are the operationalizations of the units so that measurement can be performed; and **testable hypotheses** are the propositions in operationalized form.

3.2.3 Purpose of Theory Development

Several authors have identified the main motives for the development of theory:

- The first is the organization and integration of all knowledge gathered in a particular field. (Patterson, 1980) When this knowledge is organized parsimoniously and communicated clearly, a complex reality can be understood more readily. (Bacharach, 1989; Dubin, 1976)

- The second purpose of theory is to reveal and explain the relationships among entities, some of which may not always be easily observed. (Dubin, 1976) The existence of these relationships is often subject to empirical testing.

- The third purpose of theory is to allow for the prediction of the value or magnitude of one or more units of the theory. (Dubin, 1976) Good theory permits for such an understanding that decisions can be made regarding its future states.

According to Whetten (1989), six questions need to be answered by a theory. These building blocks should be considered when developing a theory.

- **What?** This question relates to which constructs and variables are part of the theory, in other words, what the theory is about. Whetten argues for both comprehensiveness and parsimony in this aspect.

- **How?** This question relates to the interrelationships among the constructs and variables of the theory. Such interrelationships are needed to create order and, possibly, imply causality as part of the theory.

- **Why?** This question relates to the explanation and justification of the proposed interrelationships among the constructs and variables. While it is possible to test a theory to verify the What? and How? questions, this third question is usually difficult to test but necessary for a theory to gain credibility. However, Patterson (1980) asserts that answering the Why? question is an important goal of theory.

- **Who? Where? When?** These three questions place limits on the theory and serve as its boundary conditions. Such boundary conditions place limits on the generalizability of the theory. Whetten (1989) notes that such boundary conditions are often discovered in the process of testing the theory.

3.2.4 The Theory Development Process

Theory development is the general process of gathering facts, proposing explanations for their relationships, and verifying these relationships through testing. Both Dubin (1976) and Patterson (1980) state that most theory originates from real-world observations, the description of processes, and the generalization of observed data-points. Any inductive conclusion drawn from such empirical evidence is then used to deductively arrive at assertions which are subsequently subject to empirical verification. This, then, results in a feedback model of theory-building in which empirical evidence is used to refine a theory.

Dubin (1976) describes theory building as a four-step process, the first of which is selecting those things or units about which a theory is to be developed, that is, the theory's

domain. The second step is the conceptualization of how the selected units relate to each other, which Dubin (1976) calls the "laws of interaction." The third step is to specify the boundaries of the theory, within which the selected units interrelate according to the laws of interaction. The fourth and final step is determination of the different states or conditions in which the theory operates.

3.2.5 Evaluation, Verification, and Validation of Theory

Before a theory can be generally accepted, it needs to be evaluated, verified, and validated. Weick (1989) describes this process as "the demonstration, beyond pure chance, that the ordered relationship predicted by a hypothesis exists and thereby lends support to the hypothesis." However, validation of a theory usually starts before its empirical testing. A theory can be evaluated before the testing takes place and even before any operationalization into empirically measurables is performed.

Two general methods have been suggested for validating theory. Good theory should pass both of these types of validation. The first method involves the critical evaluation of a theory to confirm that it meets a number of specified requirements. The second method involves the gathering of empirical evidence.

Manual Evaluation of Theory

The manual evaluation of a theory is performed to confirm that a theory is cohesive, understandable, logically accurate, and of interest to researchers and/or practitioners. This type of evaluation can be performed before any empirical testing takes place. Various lists containing criteria for theory evaluation have been proposed. While theories which meet all such criteria are rare, the criteria provide useful guidelines when examining theory.

A set of necessary but difficult to establish criteria for a theory is comprised by the different aspects of validity. The following aspects of validity can be assessed by subjecting the theory to a critical review by experts in its domain.

- **Construct Validity**. This type of validity represents the accuracy of and consensus on the definitions of the theory's constructs. While constructs may not always be easy to define, positioning them in a nomological net to establish how they relate to other constructs is often helpful. (Nunnally, 1978)

- **Content Validity**. A theory is content-valid when the variables used to measure the theory's constructs adequately represent these constructs. When a particular test contains a representative subset of an entire construct, the test is said to be face-valid. (Nunnally, 1978) Cook & Campbell (1979) refer to this as construct validity.

- **Internal Validity**. A theory is internally valid when the proposed interrelationships are plausible or cannot be more readily replaced by other conceivable explanations. (Cook & Campbell, 1979)

Empirical Testing of Theory

Empirical testing is a common and acceptable way to evaluate or validate a theory. Dubin (1976) asserts that a theoretical model can be considered scientific only if it can be subjected to an empirical test. For a theory to be tested in this manner, its concepts need to be operationalized into measurable variables, and an experiment needs to be designed.

Bacharach (1989) argues that failure to even permit the empirical testing of a theory is indicative of a defective theory. Bacharach describes the concept of falsifiability as being the possibility of empirical refutation of a theory. Falsifiability requires that a theory is concrete enough to be operationalized and empirically tested. Theories that are very vague and difficult to operationalize fail the criterion of falsifiability.

Empirical testing can be used to validate the following aspects of a theory:

- **Reliability**. A particular empirical measure is said to be reliable when it is repeatable. Reliability can be assessed statistically. (Nunnally, 1978)

- **Predictive Validity**. Empirical evidence can determine whether the theory can be used to predict the value of a particular variable. Like reliability, predictive validity can also be assessed statistically. (Nunnally, 1978)

- **Statistical Conclusion Validity**. This type of validity establishes that the proposed relationship among the theory's units is not only plausible but also statistically significant. A study which lacks in statistical conclusion validity is a direct threat to a theory's internal validity. (Cook & Campbell, 1979)

- **External Validity**. A theory is externally valid when the results of an experiment are generalizable beyond the exact conditions (persons, settings, and times) of the experiment. (Cook & Campbell, 1979)

3.2.6 Development of the Proposed Knowledge Theory

The development process of the proposed theory consisted of several broad steps. First the subject area of the proposed theory - knowledge, its manipulation, management,

and organization - was identified. Consequently a broad literature review was performed, the results of which are contained in chapter 2. The organization and integration of the gathered materials formed the basis of the proposed theory which is set out in the following sections. The proposed theory was subsequently refined based on interactions with other researchers. Finally, one portion of the theory - which describes a structure for knowledge organization - was formally tested using the case study method.

3.3 Overview of the Proposed Theory of Knowledge

3.3.1 High-Level Components of the Theory

The proposed theory of knowledge consists of five major components. The logical arrangement of these components is shown in figure 19.

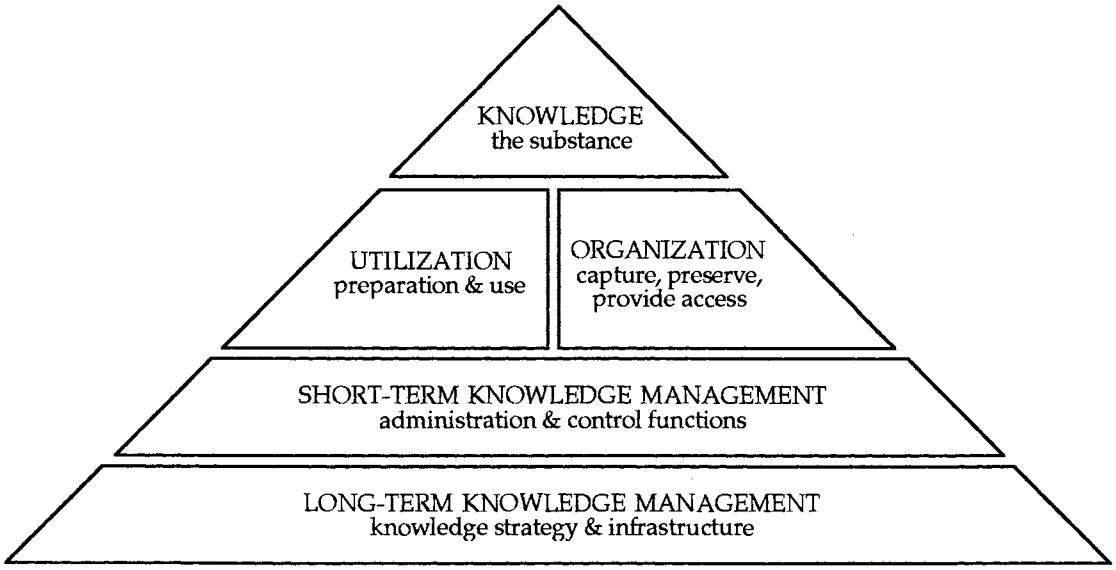


Figure 19. Proposed Theory of Knowledge

The five components of the proposed theory can be outlined as follows:

- **Knowledge**. This component contains the substance of "what is known." Enhancement and utilization of this knowledge is the objective of the knowledge activities which constitute the other four components of the theory.

- **Knowledge Utilization**. This component contains the preparation activities of the knowledge for the purposes of problem solving and decision making. It is through these activities that the value of knowledge can be realized.

- **Knowledge Organization**. This component relates to the manner in which knowledge is stored and can be accessed. The express purpose of any knowledge or data organization scheme is to enable users to find the knowledge they need when they need it. As such, knowledge organization can support knowledge utilization.

- **Short-Term Knowledge Management**. This component consists of the administrative and control functions as they relate to the application of knowledge. Short-term knowledge management, then, acts as a support mechanism for knowledge utilization..

- **Long-Term Knowledge Management**. This component consists of the long-term strategic planning for knowledge utilization and the development of an infrastructure in which knowledge can be used optimally. Long-term knowledge management, then, provides a basis for the processes that make up short-term management.

The five components of the proposed theory are described in more detail in the following sections.

3.3.2 Organizational Performance Defined

The five components of the proposed knowledge theory described in section 3.3.1 will be interrelated in the form of propositions in section 3.3.3. These propositions also link the knowledge theory components to organizational performance. It is necessary, therefore, to define what is meant by organizational performance.

Organizational performance is a concept which is often used in the management and organizational behavior literature, but which is not as often explicitly defined. Conceptualizations of organizational performance have in the past focused on the performance of individual workers (Hellriegel & Slocum, 1992) or the performance of the organization's output variables such as profit or financial ratios. Such measures of performance can then be used to assess the health of the organization overall and the achievement of organizational objectives.

Broader definitions which view organizational performance as a concept to be examined at various organizational levels have also been developed. For example, the performance-oriented framework developed by Szilagyi & Wallace (1980) examine performance as a collection of output-variables at the individual, group, and organizational level. Broadening the concept to include aspects other than measurable outputs, Watson (1992, p. 5) recognizes "method, process, procedure, product, and service performance."

To accompany the broad definition of knowledge which is developed in section 3.4.1, the definition of organizational performance shall - as part of the proposed knowledge theory - also be stated broadly. Organizational performance, then, is defined as

the capable execution of all organizational functions and processes. Thus organizational performance relates to the organizational inputs (which include raw materials, technology, and human resources), production and transformation processes (both in their design and execution), organizational outputs (in the form of both products and services), the interrelating with the organization's environment, and the functions of managerial control and planning.

Given this broad definition of organizational performance, the measurement of organizational performance can be performed in any or all of these functions. Consequently, improvements in organizational performance can also be made in any or all of the functions.

3.3.3 High-Level Propositions of the Theory

The high-level propositions of the theory suggest causal relationships among knowledge, the four knowledge activities, and organizational performance. These relationships are shown in figure 20 and are explained in the seven prepositions below.

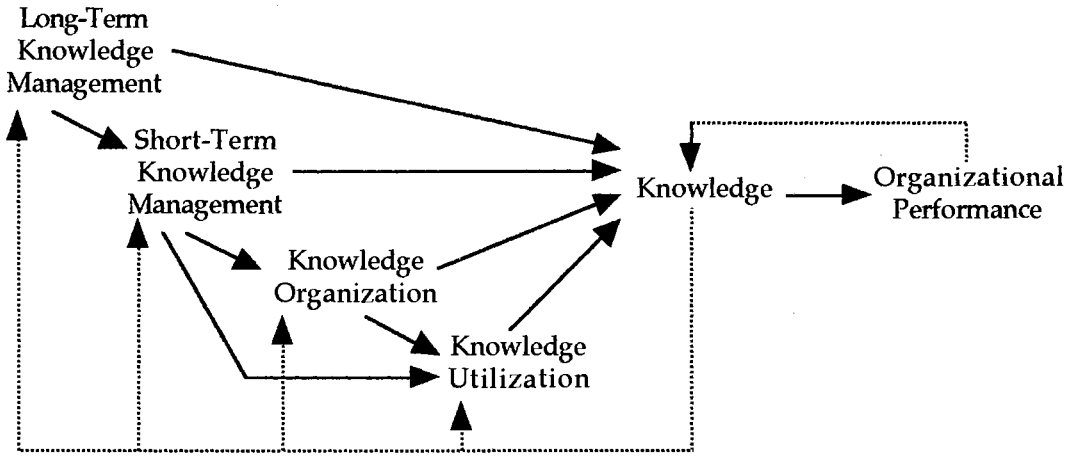


Figure 20. Proposed Relationships among the Major Components of the Theory
(Solid lines represent propositions 1-6; dotted lines represent proposition 7)

The propositions are:

1. The practice of long-term knowledge management facilitates the successful practice of short-term knowledge management.
2. The practice of short-term knowledge management facilitates successful knowledge utilization.
3. The practice of short-term knowledge management facilitates successful knowledge organization.
4. The practice of knowledge organization facilitates successful knowledge utilization.
5. Long-term knowledge management, short-term knowledge management, knowledge utilization and knowledge organization all facilitate enhancing both the organization's knowledge and the value of the knowledge to the organization.
6. Enhancement of the organization's knowledge facilitates improved organizational performance.
7. Feedback from organizational performance will result in meta-knowledge (that is, knowledge about the effectiveness of the organization's knowledge activities and its knowledge assets), which can be used to improve the knowledge activities.

Only one of the seven propositions will be tested in the course of this project. Proposition 4 will be the subject of a case study which is described in chapter 4.

3.4 Defining Knowledge

3.4.1 A Definition of Knowledge

It appears futile to attempt to define knowledge without referring to data and information. Indeed, previous definitions of knowledge (see section 2.3) show the

concepts of data, information, and knowledge to be at least related, if not hopelessly intertwined.

Definitions of data and information have become relatively standard over the years. Data is usually defined as symbols which represent or describe objects and events and their characteristics (Davis & Olson, 1984, p. 96), or as "known facts that can be recorded and that have implicit meaning" (Elmasri & Navathe, 1989, p. 3) Information, then, is generally defined as "data that has been processed into a form that is meaningful to the recipient and is of real or perceived value in current or prospective actions or decisions." (Davis & Olson, 1984, p. 200) Alter's definition of information as being "data whose form and content are appropriate for a particular use." (Alter, 1992, p. 81) is quite similar.

The definition of data provides a starting point on which to build the definition of information. It should not be surprising, then, that knowledge can be similarly defined as an extension of the definitions of data and information. Indeed, the conceptualizations of knowledge reviewed in section 2.3 seemed to indicate such. Alter's conceptualization (section 2.3.3) defined knowledge as a meta-entity which guided the use of information. Wiig's conceptualization (section 2.3.5) included a continuum which started from facts and data and was subsequently broadened to larger knowledge categories.

If information can be defined as the meaning infused to the facts that are data, then knowledge can be defined as the understanding or comprehension of both data and information. For example, the set of sales figures for widgets for the final three months of last year is a collection of data. A chart of the sales figures and the conclusion that widget sales increased at the end of last year can be viewed as pieces of information. Knowledge in this case can be viewed as an understanding of the data (where do these figures come from, how reliable or accurate are they, how can they best be combined into information, etc.) as well as of the information (why have widget sales increased, how does this affect

overall organizational performance, what does this indicate about future widget sales, etc.). The concepts of data, information, and knowledge, then, can be viewed as nested and interrelated, as shown in figure 21.

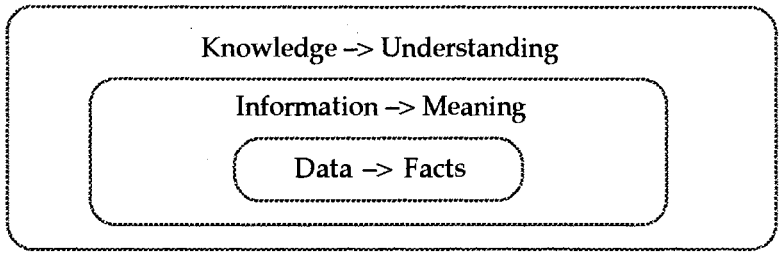


Figure 21. Data, Information, and Knowledge

The application of the definition of knowledge and its relation to data and information need not be limited to traditional data and information types. Section 2.3 mentioned that processes and other dynamic entities are part of a person's or an organization's knowledge. The definition of knowledge allows the decomposition of aspects of a process. In this perspective, a single atomic act (such as the fastening of a screw or the typing of a key on a computer keyboard) can be viewed as a process-oriented piece of data. The combination of a set of actions into a meaningful or purposeful procedure (such as the assembly of a product or the keying in of a word-processing document) is a process-oriented piece of information. Knowledge, in this perspective, is the understanding of the process and the individual acts that are part of it. This may include knowledge about why the procedure is performed in a certain way, how its actions can be rearranged to suit a particular need or preference, how the procedure can be made more efficient or more precise by changing, adding, or removing particular actions, etc. For example, for the assembly of a product, process-oriented knowledge would include a design for automating product assembly that is done by hand, or a design for an assembly plant which maximizes product throughput. For the the creation of a word-processing document, process-oriented knowledge would include the reasons why word-processing is

favored over using a typewriter, or the motives for a back-up strategy of word-processing files.

The definition of knowledge as being understanding makes it a substance that is directly affected by people. One's understanding of something is often influenced by opinions, experience, biases, training, etc. Consequently knowledge originates and usually resides with people. However, from this starting point, knowledge can be externalized either by making it explicit, formulating it, and encoding it, or by allowing it to indirectly diffuse throughout the organization, its structure, its culture, its processes, and its products. Consequently knowledge can be viewed as existing in internal (to people), explicit (written, drawn, or encoded), or embedded form (implicitly included in other entities).

Knowledge is understanding in internal, explicit, or embedded form.

Knowledge in and of itself is a relatively inert substance. Just as facts (data) can exist without being acted upon, so can knowledge. Knowledge holds value for the organization by having the potential to improve organizational performance (see section 2.2). However, to realize this value, it has to be used and applied to problem solving or decision making situations (see section 2.4).

3.4.2 A Description of Knowledge

The simple definition of knowledge as being internal, explicit, or embedded understanding hardly appears to do it justice. From the conceptualizations of knowledge by Alter, Badaracco, and Wiig (see section 2.3), a broader description of what constitutes knowledge can be extracted. The understanding that is knowledge, then, can be said to have to following properties:

- **Knowledge is Awareness**: At the outset, knowledge is that which is known individually and collectively. This means that knowledge is initially internal in that it resides with people. The descriptions of Badaracco and Wiig imply that the concept of knowledge requires people to be consciously aware of what they know. This, then, also implies a recursive relationship, in that knowledge can contain knowledge about itself. (This recursion is hinted at by Alter's conceptualization.) It is possible for knowledge to include self-referential descriptions regarding its quality, reliability, recency, etc. This meta-knowledge can be updated in a manner similar to and concurrent with regular knowledge.

- **Knowledge is Holistic**: As hinted at by the Entity-Relationship Diagram and elaborated by Wiig, Badaracco, and Alter, knowledge is less about individual and specific facts than about whole perspectives, processes, reasoning, and theories. Knowledge can be interpreted based on a foundation of earlier knowledge, or against a background of other knowledge. From Wiig's four categories of knowledge, it becomes clear that the more complex the knowledge is, the more difficult it is to make the knowledge explicit. However, the insights offered by such complex, holistic knowledge are likely to be more valuable to an organization than the more explicit facts and data.

- **Knowledge is Dynamic**: Given that a significant portion of knowledge is made up of experiences, points of view, insights, expectations, and reasoning strategies, knowledge is likely to change over time. This is reflected in Alter's feedback model of knowledge. Given the dynamic nature of a person's or an organization's experiences, knowledge can be expected to constantly change in both content and shape.

- **Knowledge is Social**: Both Wiig and Badaracco emphasize the social and shared nature of knowledge. From Wiig's three types of knowledge, it becomes clear that

the more explicit the knowledge (such as published data), the easier it is to communicate to and share with others. However, given the aforementioned holistic nature of knowledge, the more complex and abstract types of knowledge are more difficult to externalize and communicate directly. This relationship between complexity and communicability is the key connection between Wiig's and Badaracco's conceptualization of knowledge. This relationship is shown in figure 22.

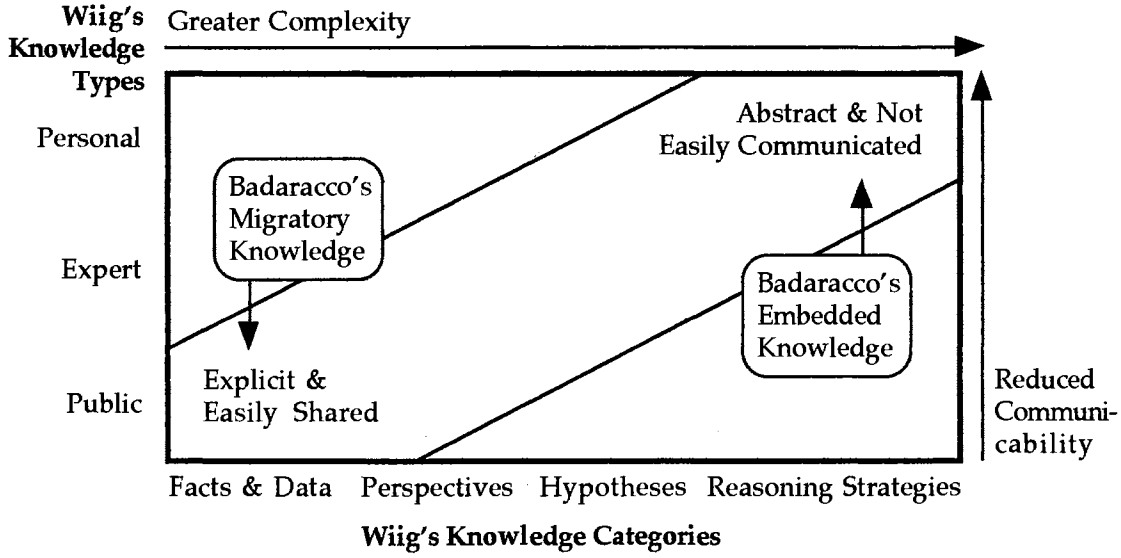


Figure 22. Knowledge Complexity and Communicability, based on Badaracco (1991) and Wiig (1988)

- **Knowledge is Relative**: Given the holistic, social, and dynamic nature of knowledge, it cannot be taken as absolute. Rather knowledge must be viewed in relation to other things, particularly other knowledge. This is similar to the way individual pieces of data can be combined into information, such as by using the Entity-Relationship model.

3.4.3 The Knowledge Molecule

Given the definition of knowledge, it is possible to distinguish a theoretical unit of knowledge. This unit is called a knowledge molecule. It's name comes from the idea that it consists of an atomic piece of data - a fact - and a surrounding context and meta-knowledge, as shown in figure 23. It's name also relates it to Wiig's Knowledge Atom (see section 2.5.4.4) who describes this as a single fact.

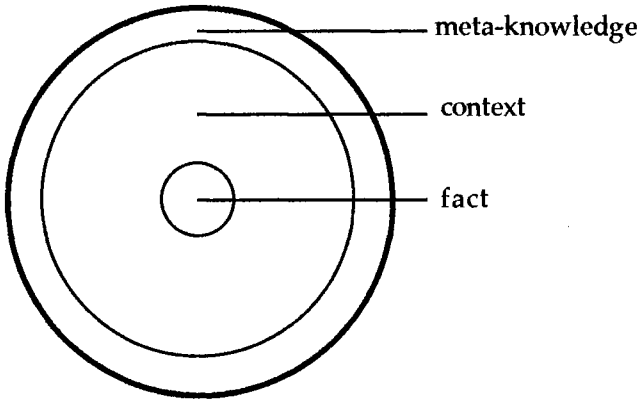


Figure 23. The Knowledge Molecule

The idea behind the knowledge molecule is that all knowledge has a basis in fact, whether that fact is true or not. This kernel of knowledge, when communicated, is surrounded by understanding, interpretation, opinion, evaluation, feeling, etc. This context, then, mixes the meaning of the fact (commonly defined as information) and the understanding of the fact (defined earlier as knowledge), thereby acknowledging the difficulty of distinguishing between meaning and understanding. The final layer of the molecule is meta-knowledge, that is, knowledge which relates to the quality, reliability, recency, source, etc., of both the fact and the understanding. This meta-knowledge is closely related to the context-layer, but is considered separately here to emphasize the additional dimension it brings to the knowledge.

Knowledge molecules seldom are taken individually. This is similar to the use of data: a singular piece of data is rarely useful. It is in the context of a group of knowledge molecules that an individual knowledge molecule becomes meaningful. For example, a single name is just that - a name. It is not until it is included along with other names and other attributes describing a person in a customer- or employee-file that this piece of data becomes valuable. The entity-relationship model (see section 2.3.2) is another method which combines pieces of data to describe entities and their associations. Knowledge molecules, then, should also be seen in how they interrelate.

A group of separate knowledge molecules can be combined in many different ways. Just as a group of words can be combined into various sentences and just as chemical molecules can be combined into different materials, knowledge molecules can be combined in various ways. Each distinct combination of the knowledge molecules presents the overall knowledge in a different way and may offer a new perspective or understanding of the knowledge. This echoes Wurman's comment on the reason for his five general knowledge organization methods (see section 2.5.4.2) being that each of these methods "will permit a different understanding of the information." (Wurman, 1989, p. 59)

Because knowledge molecules are not as specific as atomic data elements, their interrelationships also are not as clear-cut. Consequently, three general types of relationships can be distinguished by which knowledge molecules can be combined: they can be linked, they can overlap, or they can communicate, as shown in figure 24.

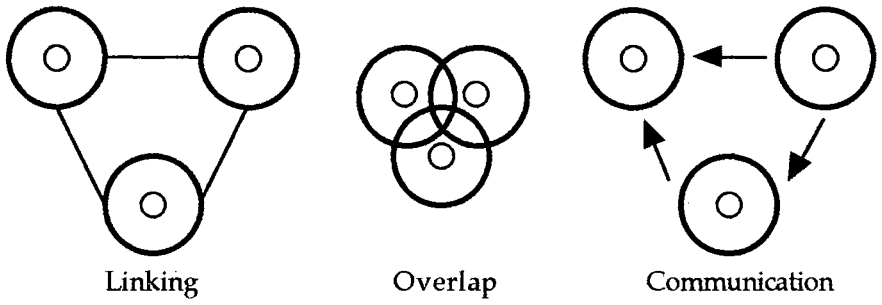


Figure 24. Linking, Overlapping, and Communication of Knowledge Molecules

- A **linking** relationship occurs when the subject areas of two or more facts and their accompanying contexts are associated with the same concept or topic. Even though the understanding of the different facts may differ, understanding of how the set of facts can be combined into a more informative whole requires the understanding of the various contexts. For example, the different functions in an organization (such as marketing, finance, production, etc.) each require different insights and approaches to understanding. However, to understand the organization as a whole, one needs to link the various contexts of the different departments and functions.

- An **overlapping** relationship occurs when different facts share a same or very similar meaning or interpretation. When knowledge molecules overlap, it is only their context which can overlap. (When their facts overlap, this would mean than the facts are identical, which would mean that the knowledge molecules would have to overlap almost completely and are subsequently virtually identical.) For example, the understanding of corporate accounting reports shares much of the understanding of corporate finance reports, and vice versa.

- A **communication** relationship occurs when context-matter is exchanged between separate knowledge molecules for the purpose of enhancing the context of the molecules, that is, to increase the understanding of a fact based on understanding

which has been developed for another fact. For example, understanding of the organizational function of new product development can be enhanced by understanding developed in the manufacturing and marketing functions.

The concept of the knowledge molecule and how it relates to other knowledge molecules mirrors the well-established theory of object-orientation (Parsaye, et al, 1989, pp. 97-159). An object consists of data surrounded by the methods which manipulate it and which enable its manipulation and application. A knowledge molecule consists of a fact - similar to a piece of data - surrounded by the context which enables its manipulation, application, and understanding. The linking of knowledge molecules is mirrored by the manner in which objects can be linked in an object-hierarchy based on the inheritance of data and methods. The overlap of knowledge molecules is similar in the manner in which objects can share methods. Finally, the communication between knowledge molecules is similar to the message-passing mode of communication between objects in the object-oriented model. These two theories, however, differ greatly in the content of what is being modeled in the knowledge molecules and objects.

3.5 Knowledge Utilization

3.5.1 Introduction

As described in section 2.4, realizing the value of knowledge requires its application to decision making and problem solving. This section develops a set of six knowledge utilization processes (section 3.5.2), and relates these knowledge utilization processes to data utilization (section 3.5.3) and to the previously proposed knowledge molecule (section 3.5.4).

3.5.2 Knowledge Utilization Processes

Given the dynamic nature of knowledge, it is necessary to examine the processes by which the form and content of knowledge can be changed. This section, then, examines the utilization and manipulation of knowledge, that is, the activities by which knowledge can be deployed, exploited, and altered. It is possible to distinguish six knowledge manipulation processes in which all knowledge utilization activities can be categorized. These processes have been derived from the relational operators, as well as of Wiig's six knowledge activities. (See section 2.4.2.) However, the applicability of the relational operators is limited to traditional data. Wiig's knowledge activities, on the other hand, are considered mainly as cognitive processes rather than as actual knowledge manipulators.

The six knowledge utilization processes are:

- **Knowledge Creation**: This process involves the creation of all-new knowledge from scratch, research, theorizing, analysis, etc. This is a difficult and unstructured process.

- **Knowledge Discovery**: This relates to the detection of new knowledge from an existing knowledge base by manipulating it in some way. Knowledge discovery activities include:
  - Decomposing knowledge by breaking it up into smaller pieces.
  - Composing knowledge by combining pieces of knowledge into a larger - and possibly more informative - whole.
  - Transforming knowledge within a single medium (such as the translation of a text).
  - Transforming knowledge to another medium (such as creating a chart out of a set of numbers).

- Structuring knowledge based on a knowledge pattern or framework.
- Filtering of knowledge by selecting pieces of knowledge which are significant for a particular purpose.
- Condensing knowledge into a summary of the whole.

- **Knowledge Deployment**: This involves the use and manipulation of knowledge without uncovering any new pertinent or usable knowledge in the process.

- **Knowledge Destruction**: This is the process of destroying or erasing existing knowledge. Knowledge can be intentionally deleted when it is considered irrelevant, out of date, or untrue.

- **Knowledge Consultation**: This process involves reading or consulting an existing knowledge base based on the results of any of the preceding knowledge processes.

- **Knowledge Exploration**: This involves reading or consulting a knowledge base which has not been extensively organized. This type of perusal may involve knowledge manipulation as the consultation develops, and it may involve the creation or discovery of new knowledge. Knowledge exploration activities include the relating of knowledge to other pieces of knowledge and putting the knowledge into a larger context.

3.5.3 Knowledge Utilization Related to Data Utilization

Although the knowledge utilization processes describe the manipulation and use of knowledge, not data, it would be interesting to compare data and knowledge utilization processes. The following, then, is the categorization of the set of relational data manipulation operators (described in section 2.4.2) according to the above knowledge

utilization processes.

- **Knowledge Creation**: Insert and Modify.
- **Knowledge Discovery**: Union, Intersection, Difference, Cartesian Product, Join, Division, Aggregate Functions, and Recursive Closure.
- **Knowledge Deployment**: Select and Project.
- **Knowledge Destruction**: Delete.
- **Knowledge Consultation**: The result of any of the relational operators can be displayed for consultation.
- **Knowledge Exploration**: No specific exploration operators are part of the relational model. However, the hypertext database architecture (briefly described in section 2.5.2) was specifically designed for this purpose.

As is clear from this classification, the relational model offers extensive tools for the combination of different data sets (relations) contained in a database for the purpose of knowledge discovery. However, as mentioned before, the model is limited in the type of knowledge (text or numeric data in fixed-length fields) it can contain.

3.5.4 Knowledge Utilization and the Knowledge Molecule

Finally, the knowledge utilization processes can also be viewed in regard to the knowledge molecule developed in section 3.4.3. It must be noted that these processes are intended to refer to the manipulation and use of actual knowledge, not to the rather abstractly defined knowledge-unit. Still, examining these processes as operators on knowledge molecules results in some interesting insights.

- **Knowledge Creation**: This process is the creation of new knowledge molecules. This could involve the creation of a new fact with a new context. However, it is

could also involve the application of an existing context to a new fact, or the development of a new context for an existing fact. The creation of any new knowledge molecule would likely lead to changes in the context and meta-knowledge of other molecules, given that the new molecule takes its place in the body of knowledge.

- **Knowledge Discovery**: The various knowledge discovery processes all involve the manipulation of an existing set of knowledge molecules, such as for a decision-making or problem-solving purpose, in which new knowledge is uncovered. The result of these processes might be changes in the contexts of existing molecules as insights are gained, or the creation of new molecules as independent new contexts are developed for existing facts. These processes, therefore, overlap somewhat with knowledge creation.

- **Knowledge Deployment**: This process involves the use of a fact and its context without the uncovering of new pertinent or usable knowledge occurring. Given that many decision-making and problem-solving activities generally result in new knowledge through learning, knowledge deployment is likely to be limited to reporting activities. Deployment, therefore, is likely to be limited to the making explicit of an internal knowledge molecule, or the repeated application of a knowledge molecule to a structured process which does not require the development of new insight.

- **Knowledge Destruction**: The deletion of a knowledge molecule, particularly when they are internal, would be analogous to the human act of forgetting. However, unlike the destruction of the more specific pieces of data, it is likely that a portion of a knowledge molecule context could survive its molecule's destruction if it has been shared with other molecules.

- **Knowledge Consultation**: This process involves the examination of knowledge molecules resulting from the creation, discovery, and deployment processes. Such examination has the potential to lead to additional knowledge discovery and thus result in the creation of new knowledge molecules.

- **Knowledge Exploration**: Unlike the traditional database models, knowledge molecules allow for exploration when attempts are made at molecule linking, overlap, and communication. Given the rather fuzzy nature of the molecule context, these three processes are not fully structured. Therefore, plenty of opportunities exist for the creation and discovery of new knowledge. A good example of knowledge exploration would be a conversation or discussion among experts in related fields who are cooperating on solving a particular problem.

3.6 Knowledge Management

3.6.1 Introduction

Like any valuable resource, the knowledge which exists in an organization needs to be managed in order to facilitate its use. Without a directed effort to manage knowledge utilization, the accuracy, timeliness, and completeness of knowledge can be called into question. The utilization of knowledge requires that accurate and complete knowledge is available when needed. This, then, is the result of effective knowledge management.

A distinction can be made between short-term and long-term knowledge management processes. The descriptions of these processes are the result of the combination of Wiig's process-oriented theory (Wiig, 1990) and Peters' infrastructure-oriented theory (Peters, 1992).

3.6.2 Short-Term Knowledge Management

Short-term knowledge management processes ensure the ability of an organization to utilize its knowledge on a day-by-day basis. Essentially, these are meta-activities, which do not directly deal with the knowledge content, but with the knowledge collection as a quantity. The substantially interrelated short-term knowledge management processes are:

- **Knowledge Acquisition**: This ongoing process involves the systematic procurement of knowledge by an organization or individual for the purpose of utilization. The more formalized this process becomes, the more likely that knowledge needs are being met.

- **Knowledge Assessment**: This ongoing process involves the evaluation of the quality of the knowledge that exists in the organization, as well as the examination of knowledge needs. In this process, redundant, out-of-date, or inaccurate knowledge can be identified, as well as knowledge gaps. The meta-knowledge layer of the knowledge molecule (see section 3.4.3) provides the knowledge needed for this process.

- **Knowledge Control**: This process involves the monitoring of the knowledge utilization processes in order to ensure that knowledge is used efficiently and appropriately and that proprietary knowledge is safeguarded.

- **Knowledge Transfer**: This involves the transfer or distribution of knowledge from a source to a destination. This could be between two people, between two knowledge bases, or between a person and a knowledge base. The transfer of knowledge emphasizes the shared and social aspect of knowledge and relates to Badaracco's concept of embedded knowledge (see section 2.3.4).

3.6.3 Long-Term Knowledge Management

The purpose of long-term knowledge management is to bring a strategic, organization-wide perspective to the handling of the knowledge resource. It is not so much a set of particular processes, but rather an approach for dealing with knowledge as a strategically important organizational asset. Long-term knowledge management, then, can be viewed as consisting of the following two aspects:

- **Knowledge Infrastructure**: The creation, development, and maintenance of an infrastructure in which knowledge utilization and short-term knowledge management processes can be performed is a key requirement for the success of these processes. The knowledge infrastructure includes physical elements (such as meeting rooms, computers, telecommunications networks, etc.) as well as intangible elements (such as function descriptions, a dedicated resource for the support of knowledge workers, and the organizational structure). The knowledge infrastructure also includes allocated resources for the maintenance and further development of the infrastructure, short-term knowledge management, and knowledge utilization. This aspect of long-term knowledge management relates closely to Peters' approach to knowledge management as described in section 2.4.3.3.

- **Knowledge Strategy**: The guiding force behind the knowledge infrastructure and the processes it supports is the knowledge strategy. The objective of this strategy is to foresee future needs and developments, and to - ultimately - ensure long-term benefits of knowledge to the organization. The organizational commitment necessary for this strategy to succeed requires that the knowledge strategy be developed at the highest level of the organization.

3.7 Knowledge Organization Structure

3.7.1 Introduction

This section describes the design of a general structure for knowledge organization purposes. Given the variety of knowledge structures described in section 2.5.4, it might seem difficult, if not impossible, to design a single, general knowledge structure. However, the need for a sound knowledge organization structure is real. If knowledge structures are to communicate and exchange knowledge, they need to have a common base which would enable this exchange. Moreover, for individuals searching for knowledge in a variety of knowledge-bases, a common structure would increase both the efficiency and the effectiveness of the search.

This knowledge organization structure described in this section, then, does not organize a particular set or instance of knowledge. Rather, it provides for a general structure for organizing knowledge. As such it is broadly applicable in a variety of settings and for a divers set of knowledge collections. In other words, the general structure does not describe how to organize a particular body of knowledge, but rather how to organize knowledge in general. Based on this general knowledge organization structure, various specific implementation structures can be developed. One such implementation is described in chapter 4.

The knowledge organization structure design is described in the following sections:

- Section 3.7.2 explains the reasons for multidimensional nature of the structure.
- Section 3.7.3 describes the organizing principles which underlie the structure.
- Section 3.7.4 reviews the dimensions of structure used by the knowledge structures

reviewed in section 2.5.4.

- Section 3.7.5 describes the three dimensions of structure used by the general knowledge organization structure.
- Section 3.7.6 presents the full knowledge structure and presents some implementation examples.

3.7.2 The Need for Multidimensionality

The survey of knowledge structures described in section 2.5.4 reveals that a variety of methods exist by which knowledge can be organized. Some of the structures decompose the knowledge content, others examine the purpose to which the knowledge is to be put. Clearly, then, a common knowledge structure would have to accommodate more than one aspect of organization. In other words, the structure would have to be multidimensional. A multidimensional knowledge structure would provide for multiple access paths to a single piece of knowledge. Virtually all of the surveyed knowledge structures are one-dimensional - that is, they provide for only a single access path. This aspect of these knowledge structures - the absence of an alternative method of access - is the key shortcoming which limits the general applicability of the structures.

A case for multidimensionality is implicitly made by Wurman's "five ultimate hatracks." (Wurman, 1989, p. 59) Wurman's description of five general structuring methods (see also section 2.5.4.2) would at first seem to suggest that no single structuring method can apply to all knowledge. However, it can also be interpreted to call for a multidimensional knowledge structure. Wurman describes how a large set of knowledge can be organized by using a combination of several of the structuring methods, the result of which is a multidimensional structure. Consequently, well-chosen dimensions should result in a solid and generally applicable knowledge structure.

The question now becomes, which dimensions need to be included in the structure, and how should these dimensions be filled in? The answer to this question should be based on the organizing principles which underlie the knowledge structure. These principles will be described in the following section.

3.7.3 Organizing Principles Behind the Knowledge Structure

The following five organizing principles are both the starting point and the justification for the knowledge structure design. The principles were inspired by the philosophies of knowledge organization described in section 2.5.2 and the features of the various knowledge organization structures described in section 2.5.4. When applied, these principles should result in a general knowledge structure which is both usable and robust. At the end of section 3.7.6. the general knowledge structure will be evaluated for the extent to which it meets these principles.

1. **The knowledge structure should combine purpose and content.**

Although often the knowledge gathered into a knowledge base is to be contained there for the specific purpose of archiving and subsequently distributing it, a knowledge structure should not be purely purpose-based. Neither should it be organized solely by the knowledge content; Henriksen makes a sound argument for the inclusion of purpose in a knowledge base organized solely by content (see section 2.5.2). Consequently, a knowledge structure should combine aspects of the content- and purpose-based methods of knowledge organization, reflecting the insights of the writings of both Nelson and Henriksen.

2. The knowledge structure should apply to organization and retrieval.

While all of the knowledge structures described in section 2.5.4 could be applied to the organization of knowledge in a knowledge base, not all imply the use of their structures for retrieval. For example, the chief method of knowledge retrieval in the Dewey Decimal Classification method (section 2.5.4.4) is the keyword search, not the traversal of its knowledge structure. In addition, Wiig's descriptions for both the proficiency-level and increasing-detail structures (section 2.5.4.4) fail to address the process of retrieval from these structures entirely. However, considering Henriksen's insistence on access methods other than keyword search (section 2.5.1), a sound knowledge structure needs to provide support for both the knowledge organization and knowledge retrieval processes.

3. The knowledge structure should be generally applicable.

Some of the reviewed knowledge structures are limited in the types of knowledge they could contain. The most obvious example is the IBIS structure (section 2.5.4.3). This model is well suited for rhetorical, conceptual, or theoretical knowledge, but it lacks the capacity to deal effectively with procedural, skill-based, mechanic, or applied knowledge. In a similar manner, the precedence-based structure applies (section 2.5.4.4) only to those knowledge materials the content of which is cumulative in nature. The limitations of these structures appear to be caused by the unidimensionality of their design.

However, a multidimensional model could allow for a general knowledge structure. As discussed in section 3.7.2, Wurman's five-dimensional method implicitly allows for this possibility. The key to a broadly applicable knowledge structure, then, is the choice of broad yet usable dimensions.

4. The knowledge structure should be dynamic.

The previous organizing principle suggests that a single set knowledge structure dimensions need to be chosen so that the structure is generally applicable. However, this need not imply that the these dimensions may not vary in what is contained in them. Indeed, if the content-aspect is to be a part of the knowledge structure (as suggested by the first organizing principle), the implementations of the knowledge structure in different settings should result in drastically different content dimensions. Therefore, the knowledge structure, and its dimensions, should be sufficiently dynamic to allow for customization in different settings.

A second aspect of the dynamic nature is the need for change and extendibility. It is quite likely that after a knowledge structure has been in use for some time, the categories contained within its dimensions many need to change. It should therefore be possible to add new categories and remove the ones which are no longer useful. While this would appear to be an issue more relevant to the implementation of a particular instance of the knowledge structure, it is imperative that the conceptual knowledge structure itself allows for this possibility.

5. The knowledge structure should be designed for consistent application

It is important to design the knowledge structure so that when it is applied it will be used consistently. Two persons placing a same piece of knowledge in the knowledge structure should place it at the same location. Two persons searching the knowledge structure given a single retrieval objective should be able to locate the same piece of knowledge. This, then, requires that the knowledge structure itself be simple, comprehensible, and possibly even intuitively obvious. In addition, this requires that applications designed to use the knowledge structure (such as the prototype application

outlined in section 1.2) support and encourage consistent use of the structure.

Finally, it is also necessary at this point to mention a set of aspects which should not be applied to the development of the knowledge structure. These are the limitations imposed by the current state of computer hardware and software. Whatever such limitations are at the moment, many of them are likely to be solved soon, especially when a pressing need for a solution presents itself. Technological feasibility, therefore, should not be taken into consideration when developing a general knowledge structure.

3.7.4 Review of Structure Dimensions

Before selecting the dimensions for the general knowledge structure, it would be worthwhile to examine the dimensions used in the knowledge structures described in section 2.5.4. Although it would appear that these structures utilize a large variety of structures, they can be categorized as being content-based, purpose-based, and both content- and purpose-based. These categories, which reflect the two knowledge organization philosophies described in section 2.5.2, will be used as a guide to evaluating the knowledge structures and as a basis for the general knowledge organization structure design.

Content-based structures include Increasing Detail, Dewey Decimal Classification, and Frame-Based Organization. The IBIS structure is the only structure which is solely purpose-based. The structures which combine aspects of content and purpose are Wurman's set of five methods, Wiig's Proficiency Level structure, and the Precedence-based structure. These structures, then, result in a number of possible knowledge organization dimensions which are described below.

Content

The content-based aspects organize knowledge based on features of its content. The content-based aspects of knowledge organization described in section 2.5.4 include the following:

- Organization of a broad area of knowledge according to the topics it contains. (The four levels of meta-knowledge in Wiig's detail-based method and the first three levels of Dewey Decimal Classification, both from section 2.5.4.4.)
- Organization of the knowledge within a particular topic according to increasing detail. (The three levels of increased detail in Wiig's detail-based method and the sub-section levels of Dewey Decimal Classification, both from section 2.5.4.4.)
- Organization of knowledge within a particular topic based on human intake of it, such as levels of proficiency, complexity, or precedence. (Wiig's proficiency-level method and the precedence-based method, both from section 2.5.4.4.)
- Other, less specific methods. (Wurman's five broad methods from section 2.5.4.2 and the frame-based organization from section 2.5.4.5.)

Two methods of knowledge organization by content are prominent here: the organization of knowledge within a particular area into its topics and the organization of knowledge within a particular topic into successive levels of detail. While these methods appear very similar, they are in fact quite distinct. Organizing knowledge into topics and searching for a particular topic often need not take into account the detail within the topics, nor the purpose of its application. Moreover, organizing knowledge within a topic or searching for a particular detail is not likely to involve knowledge on other topics.

Purpose

Purpose-based aspects organize knowledge according to its intended use. The purpose-based aspects of the knowledge structures described in section 2.5.4 include the following:

- Organization of knowledge based on the motive of knowledge conveyance. (Wurman's five broad methods from section 2.5.4.2.)
- Organization of knowledge for the intent of structuring a debate into issues, positions and arguments. (IBIS structure from section 2.5.4.3.)
- Organization of knowledge based on training objectives and on understanding of how people learn. (Wiig's proficiency-level method and the precedence method, both from section 2.5.4.4.)

There does not appear to be a common thread in these three purpose-based aspects. When also considering the purposes for some other forms of communication, the issue becomes even more confusing. For example, Alter (1992, pp. 393-394) describes a method which organizes electronic mail messages by purpose into notices, action requests, and commitments. Parnell (1990) describes the three basic purposes of giving a speech to be imparting information, persuading or promoting a better understanding, and inspiring action.

Organization by purpose, then, may depend on the context in which it is used and possibly even the medium by which it is conveyed. Consequently, when taken as the sole basis of a knowledge structure, purpose-based structuring can lead to a large variety of structures, each of which need to be learned separately before they can be used. It is not surprising, then, that only one of the reviewed knowledge structures is based solely on purpose. It would appear, however, that purpose can be used to provide a useful additional

structure to a knowledge collection which also uses a content-based structure.

Content & Purpose

The following approaches to knowledge structure result when content- and purpose-based organization aspects are considered simultaneously:

- The purpose of conveying knowledge results in the selection of a particular content-based organization method. (Wurman's five broad methods from section 2.5.4.2.)
- The purpose of training gives rise to the decomposition of knowledge within a particular topic into eight proficiency- or complexity-based levels (Wiig's proficiency-level method from section 2.5.4.4) or an unspecified number of precedence levels (precedence method from section 2.5.4.4).

The above two methods appear to agree that knowledge content - particularly within a specific topic - can be organized based on the purpose to which it is to be put. In other words, purpose provides the initial means of structure, after which content-based structuring is applied, rather than the other way around. Such an approach to knowledge organization would facilitate the search for and retrieval of knowledge for a given purpose.

3.7.5 Knowledge Structure Dimensions

Based on the knowledge structure organizing principles (section 3.7.3) and the dimensions of knowledge used in the reviewed knowledge structures (section 3.7.4), this section describes the dimensions which define the knowledge structure. As in the previous section, three general dimensions will be considered: content, purpose, and the simultaneous use of content and purpose (operationalized as the detail/complexity dimension).

The Content-Dimension

Section 3.7.4 focused on two general methods for content-based knowledge organization: decomposition of a knowledge area into topics and decomposition of a topic into detail. Of these two, the first appears to be most purely content-based. A selection among various disciplines can be performed for a number of purposes, not necessarily any particular one. At this higher level, the disciplines can be viewed as to how they relate (a content-based aspect) regardless of the purpose of their application. However, the decomposition of a topic into its details was found to contain specific aspects of purpose. The exploration of a particular topic appears to require a particular purpose or point-of-view to assess which level of detail and which entities and relationships are relevant. Therefore, the content-dimension of the knowledge structure will decompose a broad knowledge area into the topics it contains. The decomposition of a topic will be the subject of the third dimension, the detail/complexity dimension.

The content dimension can be defined as a hierarchical decomposition of what the knowledge is about, what discipline does it belong to. It becomes necessary, then, to determine how many levels to assign to this pure-content dimension. Wiig's method (Wiig, 1992-a, p. 140) contains four of these levels (domain, region, section, and segment) although the fourth of these starts to contain some content of the topic, rather than being a description of the topic itself. Dewey Decimal Classification (Comaromi, et al., 1989) contains three of these levels (main class, division, and section). It would therefore appear that three levels of this dimension would be sufficient. These three levels are named and defined as follows:

- **Area**. These are general disciplines for which knowledge exists. Often a single environment, such as an organization, will have the need for knowledge in several areas. These areas can be defined broadly. For example, an organization's relevant

knowledge areas could include computer science, engineering, business, etc.

- **Subject**. Within an area, different subjects may be identified which cover a somewhat more specific discipline or specialty. For instance, within the area of computer science, subjects would be systems development, end-user computing, databases, decision support systems, etc.

- **Topic**. This level refers to a specific concept within a given subject or area of expertise. For instance, within the subject of databases, topics would include hierarchical databases, the relational model, hypertext, etc.

The Purpose-Dimension

Purpose-based decomposition, as mentioned in section 3.7.4, is very much context dependent. Moreover, some of the purpose-based aspects could be viewed as categories (such as training criteria), while others could be perceived as hierarchies (such as IBIS). Given the high level of uncertainty as to this dimension, it has been designated as a single level of purpose-categories. The reason for this is that any purpose-hierarchy could be flattened into a reasonably comprehensible single-level structure while a single set of categories cannot always be converted into a comprehensible hierarchy. The number of categories in this continuum is unspecified. For example, for the topic of hypertext databases, the different purposes for knowledge on this topic would include application development using hypertext, education on the hypertext architecture, the use of a hypertext database, and the conducting of research into hypertext databases.

The Detail/Complexity Dimension

As indicated earlier, the organization of a general knowledge area into the topics it includes can be done purely on a content-decomposition basis. However, the organization of knowledge content within a particular topic is generally based on the purpose of its application. As Wiig puts it, "when we 'know' something, we frequently know it from a particular perspective or for a particular purpose with a specific use in mind." (Wiig, 1992, p. 85.) Such combinatory decomposition can occur by level of detail (such as the lowest four levels of Wiig's detail method or the bottom levels of Dewey Decimal Classification - see section 2.5.4.4) or by proficiency level (such as Wiig's proficiency-level method or the precendence-level method - see section 2.5.4.4). This type of decomposition has been generalized as the detail/complexity dimension.

The name of this dimension reveals a parallel set of categories. The aspect of detail of this dimension relates to the depth of facts and their interassociations within a topic. Given a particular purpose, the required level of detail of a topic's entities and relationships can be determined. The aspect of complexity of this dimension relates to the proficiency or capability of a person to comprehend increasingly complex facets of a topic. Given a person's level of proficiency, the appropriate level of complexity and detail of a topic's entities and relationships can be determined. The similarity of the aspects of detail and complexity has resulted in a matching set of dimension-levels.

The possible number of levels of detail ranges from four (Wiig's detail method) to seven (a common cut-off point in the Dewey Decimal Classification). The problem with DDC is that these within-topic levels have not been defined. Wiig, however, explicitly defines this segment, element, fragment, and atom levels. A possible number of levels of complexity would be eight (Wiig's proficiency-level method). However, Wiig's levels are so thinly defined that the consistent application of all eight levels might not be practically

feasible. However, by matching levels of complexity to levels of detail, a clearer division would be possible.

Consequently, four categories were chosen for the levels of the detail/complexity dimension. These categories can be defined as follows:

- **General / Introductory**: A broad description of the topic, its purpose or meaning, and the arrangement of its concepts. For example, the topic of hypertext for education purposes would require a general introduction describing Nelson's idea of and purpose behind hypertext.

- **Concepts / Beginner**: Description of the particular concepts and processes of which the topic consists. This includes the structure of its objects. For example, concepts in hypertext which would need to be explained for education purposes include nodes, links, webs, graphs, etc.

- **Objects / Intermediate**: Knowledge of the objects of a topic and how they interrelate. For example, education on hypertext links would need to describe the referential and organizational links, explain how they differ in their nature and use, and justify why they are both needed in the hypertext model.

- **Facts / Advanced**: Atomic facts or specific abstractions, their interrelations, interpretation, and meaning. For example, education on hypertext referential links would need to explain why two nodes need to be interconnected using a referential link, and how such a link could be implemented.

The Detail/Complexity Dimension and Educational Models

At this point it is necessary to distinguish the categories of the detail/complexity dimension from similar categorizations in the educational literature.

The four levels of detail (General, Concepts, Objects, Facts) and their definitions can be seen as similar to Bloom's taxonomy of educational objectives for the cognitive domain. (Bloom, 1956) Bloom organizes educational objectives in the following six cumulative levels: (Bloom, 1956, pp. 201-207)

- **Knowledge**: the recognition and recall of facts, ideas, principles, etc.
- **Comprehension**: the use of the contents of a communication for the purposes of translation, interpretation, and extrapolation.
- **Application**: the correct use of comprehended materials.
- **Analysis**: the breaking down of materials to determine their elements, relationships, and organizing principles.
- **Synthesis**: the combining of elements to form a new pattern or structure.
- **Evaluation**: the purpose-based making of judgments about the value of ideas, methods, solutions, etc.

These six levels, however, more closely refer to the purpose rather than to the content of the knowledge. As such, they could be used to fill in the purpose-dimension of the structure. Within each of these six levels, a variety of detail/complexity levels can occur. The levels of detail, as defined for the knowledge structure, do not necessarily imply the objectives of comprehension, application, etc. Consequently, Bloom's taxonomy is quite different from the detail/complexity dimension of the knowledge structure.

Similarly, the four levels of complexity (Introductory, Beginner, Intermediate, Advanced) and their definitions can be viewed as similar to the proficiency levels described by Dreyfus & Dreyfus (1986). This model distinguishes five levels of proficiency: Novice, Advanced Beginner, Competent, Proficient, and Expert. These five levels model the continuum which ranges from analytic behavior (the conscious following of abstract rules and facts) in novices to skilled behavior (the application of know-how and experience) in experts. While the knowledge structure's four levels of complexity can be related to skill levels, they do not relate to the actual cognitive processes and behavior of the recipient of the knowledge. Given this perspective, the four levels of complexity and the Dreyfus & Dreyfus model are quite dissimilar.

3.7.6 The Knowledge Cube - A General Knowledge Organization Structure

A proposed general knowledge organization structure combines three separate aspects of structure: content, purpose, and detail/complexity. Consequently, a three-dimensional model results, called the Knowledge Cube. This model is shown in figure 25.

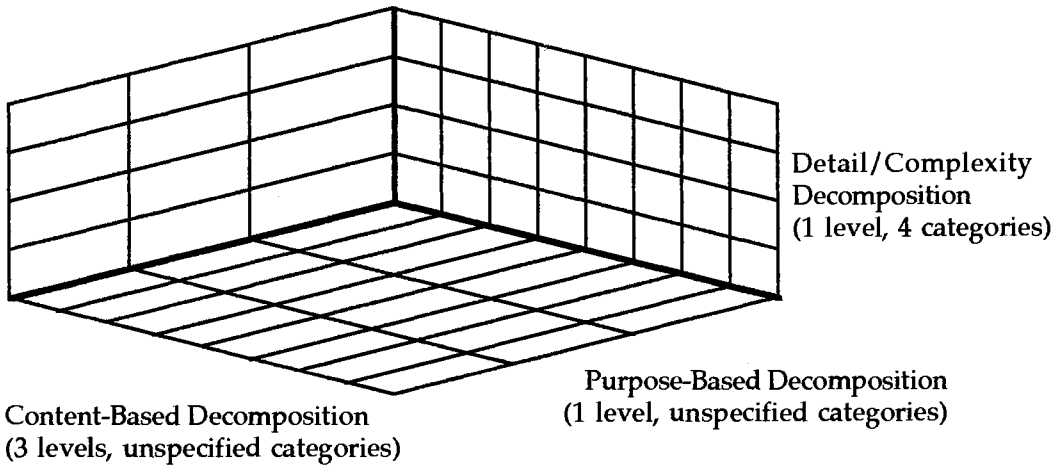


Figure 25. The Knowledge Cube

The three axes of the Knowledge Cube refer to the content-based, purpose-based, and detail/complexity-based organization of knowledge. The content-based axis consists of three levels (area, subject, and topic), but instances of the structure will differ in the number of categories assigned to each level. The purpose-based axis consists of a single level of categories appropriate to an implementation context. The detail/complexity-based axis, the categorization which combines content and purpose, consists of four levels (general, concept, object, and fact), but instances of the Knowledge Cube will differ in the number of categories assigned to each level.

This three-dimensional structure lends a spatial notion of the knowledge structure. Given the proper three-dimensional visualization and manipulation methods, the Knowledge Cube could be searched in a navigational manner for a particular piece of knowledge with any axis as its starting point. Moreover, an organization using the Knowledge Cube would be able to visually inspect it to determine which parts of the structure have been filled in with knowledge materials and which parts would still need to be addressed. An example of such visualization is given in figure 26.

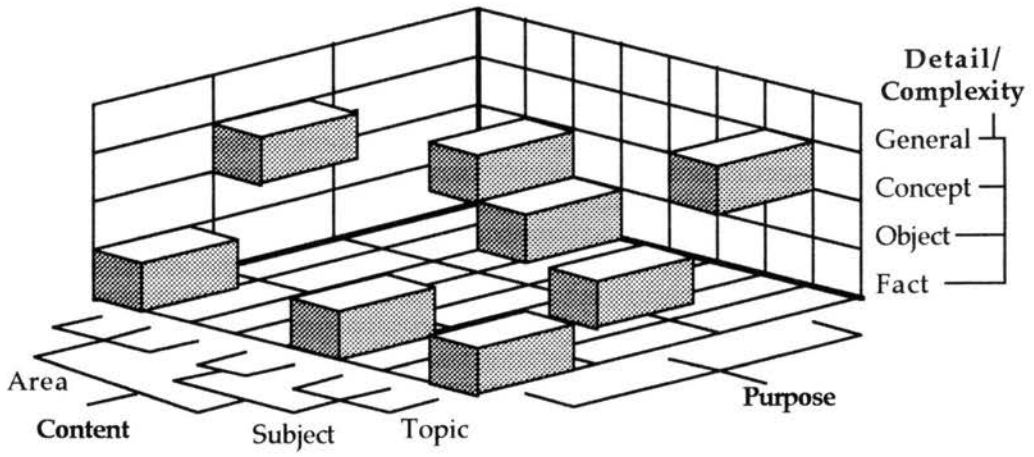


Figure 26. Sample Spatial Inspection of the Knowledge Cube

Although initial efforts at three-dimensional databases are well underway (Clarkson, 1992), such systems are still far from generally feasible given current database technologies. For this reason, it is likely that any implementation of the Knowledge Cube (see chapter 4) would require the three-dimensional knowledge structure to be "flattened-out" into a two-dimensional data-structure. Given the proper design, such a two-dimensional implementation structure would still allow for most, if not all of the advantages of the three-dimensional knowledge structure.

Finally, the Knowledge Cube needs to be examined for the extent to which it meets the organizing principles set out in section 3.7.3.

1. **The knowledge structure should combine purpose and content.**

   The Knowledge Cube combines both content- and purpose-aspects of knowledge organization as required by the first principle.

2. **The knowledge structure should apply to organization and retrieval.**

   While the use of the Knowledge Cube for the organization of knowledge is clear, its use for knowledge retrieval is not immediately obvious. The same axes which allow for the organization of knowledge could enable search and retrieval. However, much of the quality of the retrieval function rests with the actual implementation of the Knowledge Cube.

3. **The knowledge structure should be generally applicable.**

   The design of the Knowledge Cube allows for a broad range of applications because it offers a guide to the organization of knowledge, not a specific implementation for a single area (such as IBIS) or the organization based on a single dimension (such as DDC).

4. **The knowledge structure should be dynamic.**

   The manner in which the three dimensions of the Knowledge Cube are defined allow for changes in and new additions to a knowledge base to be incorporated into the general structure. The enabling of the actual process of doing so, however, is an implementation issue.

5. **The knowledge structure should be designed for consistent application.**

   This principle cannot be realistically be addressed until the Knowledge Cube is actually implemented. Only then can the consistency of its application be observed. Much rests on how the person administrating the knowledge base fills in the three dimensions of the structure and on how the loading, search, and retrieval capabilities are implemented.

The Knowledge Cube, as mentioned before, can be instantiated in a variety of settings. The development of the structure for one particular instance, the organization of training materials, and the subsequent testing of the usefulness of the Knowledge Cube in practice will be described in the following chapter.

CHAPTER IV

RESEARCH METHODOLOGY & KNOWLEDGE STRUCTURE OPERATIONALIZATION

4.1 Introduction

This chapter describes the process by which the Knowledge Cube, a general knowledge organization structure developed in section 3.7.6, was instantiated for testing in an organizational setting. This process is described in the following sections:

- Section 4.2 provides a chronological overview of the research methodology used to test the knowledge organization theory in an organizational setting and the subsequent data analysis procedures.
- Section 4.3 describes how the Knowledge Cube was operationalized into a data structure and a set of knowledge insertion and retrieval procedures, resulting in a computerized application.
- Section 4.4 describes in detail the manner in which the Knowledge Cube was tested in an organizational setting using the case study method.
- Section 4.5 describes the organizational environment in which the case study took place.

4.2 Research Methodology Overview

This section describes how the operationalization of the Knowledge Cube and the subsequent research was carried out in chronological sequence. These activities follow the development of the knowledge theory (chapter 3) and test the effectiveness of the Knowledge Cube, as well as the knowledge theory's fourth proposition. Following this overview, the separate aspects of the operationalization and the research are described in more detail in the subsequent sections.

The first activity was the operationalization of the Knowledge Cube into a data structure and a computer program. This process included the transformation of the three-dimensional structure into a two-dimensional data structure. This step was needed so that existing software applications could be used to implement and test the Knowledge Cube. The operationalization of the Knowledge Cube also included the specification of the processes of knowledge organization/insertion into and search/retrieval from the Knowledge Cube.

The resulting functional design was implemented for a business environment using the MicroSoft FoxPro database management system. The application included knowledge organization, knowledge search, knowledge retrieval, and reporting capabilities. An initial prototype was tested in the researcher's academic environment. This testing focused only on the functionality of the prototype, not on the validity of the Knowledge Cube.

In the meantime, the case study method as described by Yin (1984) was selected as the appropriate method for conducting the research. Preliminary research protocols were developed to guide data collection. The goal of these protocols was to capture user experiences with the Knowledge Cube and its accompanying software application.

Given Yin's recommendation that a case study take place within a real-life context (Yin, 1984, p. 23), it was decided that the validation of the effectiveness of the Knowledge Cube for knowledge utilization purposes should take place in a business environment rather than an academic or laboratory setting. To this end, contact was established with the company in which the testing of the Knowledge Cube would take place. The company and the researcher drew up a cooperative research agreement which enabled the research to take place and which protected the proprietary materials of both the company and the researcher. In July, 1994, the researcher visited the company for an orientation of the company's practices and knowledge materials. During this initial visit, arrangements were made for a follow-up visit during which the actual testing would take place.

Based upon this first visit, company-specific data files were built into the prototype. The resulting software application was called SkillSet and it allowed for the organization and retrieval of the company's knowledge materials. At this time, the researcher also finalized the research protocols and experimental tasks which were to be used during the testing of the Knowledge Cube.

In August, 1994, the researcher returned to the company to perform the actual study to test the validity of the Knowledge Cube. Six of the company's employees had been recruited by the company's research director to take part in the study. Each participant met with the researcher twice. During the first meeting, the researcher explained the objectives of the study and introduced the participant to the Knowledge Cube and to the SkillSet application. The participant was then asked to organize five pieces of knowledge using the Knowledge Cube and the SkillSet application. The researcher then observed the participant and recorded both the participant's activities and verbal comments. Following this activity, the participant was asked to fill out a satisfaction analysis questionnaire regarding the Knowledge Cube, the SkillSet application, and the knowledge organization task.

During the second meeting, the researcher reintroduced the participant to the Knowledge Cube and the SkillSet application. The participant was then asked to retrieve pieces of knowledge from the SkillSet knowledge base, given four short business case problems. The researcher then observed the participant and recorded both the participant's activities and verbal comments. Following this activity, the participant was asked to fill out a satisfaction analysis questionnaire regarding the Knowledge Cube, the SkillSet application, and the knowledge retrieval task.

The results of both the knowledge organization and the knowledge retrieval activity can be viewed as three groups:

- **Activity Results.** These results are comprised of the objective output of the activities performed by the study's participants. These results include the categories used to organize the knowledge during the knowledge organization activity and the lists of pieces of knowledge retrieved by the participants during the knowledge retrieval activity.

- **Satisfaction Analysis Results.** These results are comprised of the participants' responses to the questionnaires administered following the knowledge organization and retrieval activities. The questionnaires addressed the Knowledge Cube, the SkillSet application, and the performed task.

- **Observation Results.** These results are comprised of the researcher's observations of the participants' behavior and verbal comments during the activities. They also include the time needed by the participants to complete the different tasks.

These results were subsequently analyzed by the researcher. The analysis of the case study data focused on the determination of common findings among the study's participants. Given the qualitative nature of the results and the small number of participants, traditional quantitative techniques could not be applied for data analysis. Instead, methods for qualitative data analysis, such as those suggested by Miles and Huberman (1994) and Yin (1984), were applied. As a first step, the results of the knowledge organization and retrieval activities were displayed, aggregated, and compared across the six participants. Then, using the processes of synthesis and triangulation, meaningful patterns were identified in the results. As a final step, the results of the case study and the subsequent data analysis were related back to the original knowledge structure theory. Finally, limitations of the research, as well as future research directions, were described.

4.3 Knowledge Cube Operationalization

4.3.1 Introduction

The Knowledge Cube proposed in section 3.7.6. is in essence a theoretical model which can be operationalized to fit different knowledge environments. The following sub-sections describe the operationalization effort performed to convert the Knowledge Cube into a standard data structure and, eventually, into an automated application for the organization and retrieval of knowledge in a business setting. This application will provide for the organization, selection, and retrieval of knowledge materials and will serve as an "intelligent" database for these materials. A visual overview of the workings of the application is provided in figure 27. As stated in section 1.2, the application will have to perform the following functions:

- Organize a given set of knowledge fragments (units) according to the developed knowledge organization framework into an accessible database.
- Provide an index or overview of the available units.
- Accept a set of objectives for training purposes.
- Select the appropriate units or unit-sequences.
- Output a list of the found units or unit-sequences.

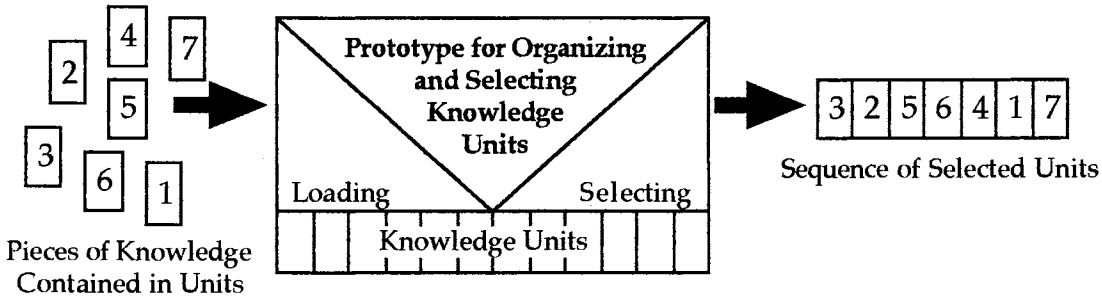


Figure 27. Prototype Overview

Using the application will be possible in two subsequent stages: **organization** and **retrieval**. In the organization stage, the application's user accepts the knowledge units , organizes them according to the knowledge organization structure, and places them in the application's database. In the retrieval stage, the user enters the selection criteria (such as topic and level of complexity) on the basis of which the application will automatically locate and retrieve the appropriate knowledge units.

The subsections on the operationalization and implementation of the Knowledge Cube cover the following topics:

- Section 4.3.2: conversion of the Knowledge Cube into a data structure.
- Section 4.3.3: description of the knowledge insertion process.
- Section 4.3.4: description of the knowledge search processes.
- Section 4.3.5: selection of the implementation platform.
- Section 4.3.6: description of the application development process.

4.3.2 Knowledge Cube Data Structure Development

As mentioned in section 3.7.6, the current state of database technologies requires for the Knowledge Cube's three-dimensional structure to be collapsed into a two-dimensional structure. However, this conversion process does not result in the elimination of the three-dimensional access to knowledge as defined by the Knowledge Cube.

This conversion was accomplished using the Entity-Relationship model (see section 2.3.2). Each of the three dimensions of the Knowledge Cube can be viewed as a separate entity. The manner in which these three dimensions intersect for the purpose of organizing knowledge is the relationship. The position of a piece of knowledge in the Knowledge Cube can therefore be modeled using the Entity-Relationship diagram shown in figure 28.

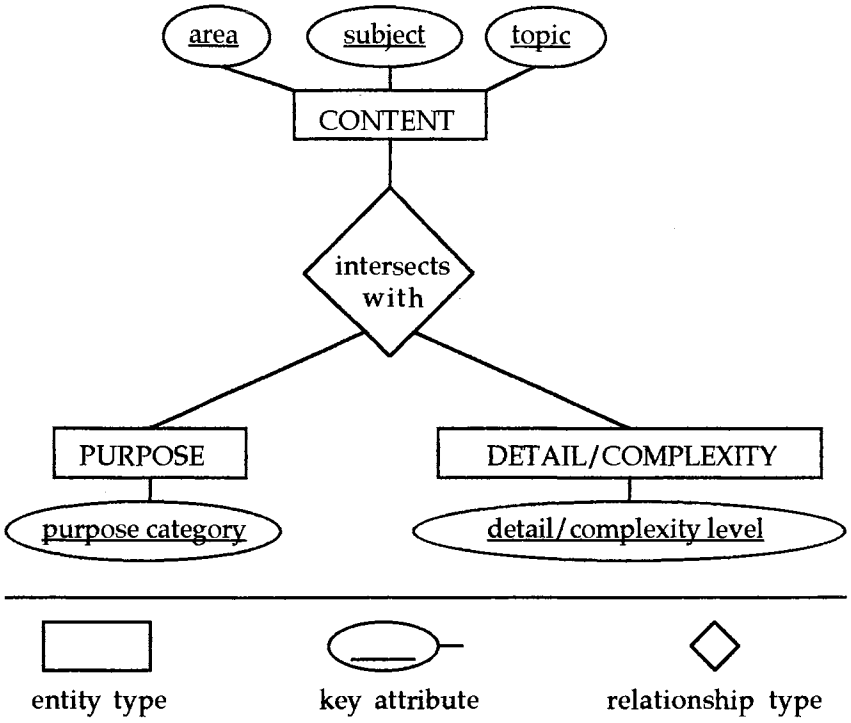


Figure 28. Entity-Relationship Diagram for Knowledge Cube

The ternary relationship called "intersects with" can be converted into a relation for the relational database model by using a standard conversion rule:

> "For each n-ary relationship type R, n > 2, we create a new relation S to represent R. We include as foreign key attributes in S the primary keys of the relations that represent the participating entity types. [...] The primary key of S is usually a combination of all the foreign keys that reference the relations representing the participating entity types." (Elmasri & Navathe, 1989, p. 331)

The relation which results from this rule effectively contains the classification of a piece of knowledge in the knowledge cube. This relation is shown in figure 29.

area	subject	topic	purpose category	detail/complexity level

Figure 29. Relational Data Structure for Knowledge Cube

By itself, this relation is not complete. Given that it is possible for two very similar pieces of knowledge to be classified the same way, identical tuples (relational database records) might occur, which is not permitted under the relational model. (Elmasri & Navathe, 1989, p. 141) A unique identification of the knowledge, such as a title or identification code, needs to be added to the relation for implementation purposes. To deal with this problem, the implementation of the Knowledge Cube will include a unique identification number to be attached to each piece of knowledge classified in the Knowledge Cube. These numbers will be generated by the automated application which implements the Knowledge Cube. (See Appendix A.3.3)

The implementation of this relational data structure can be accommodated using current relational database applications. Given that the relational database model allows for any of the attributes of a relation to be accessed directly, it can effectively simulate three-dimensional access to the knowledge. The processes of both knowledge insertion (see section 4.3.3) and knowledge retrieval (see section 4.3.4) can be implemented using the combination of a relational database system and an accompanying programming language.

Units in the Knowledge Structure/Data Structure

The Knowledge Cube data structure will be implemented using knowledge units. Each unit in the structure is assigned a unique identification number (UNIT ID) by the application. Three distinct, yet related segments are then used to describe and distinguished each knowledge unit, as shown in figure 30. These three segments are its access path, its identification and technical description, and the knowledge itself.

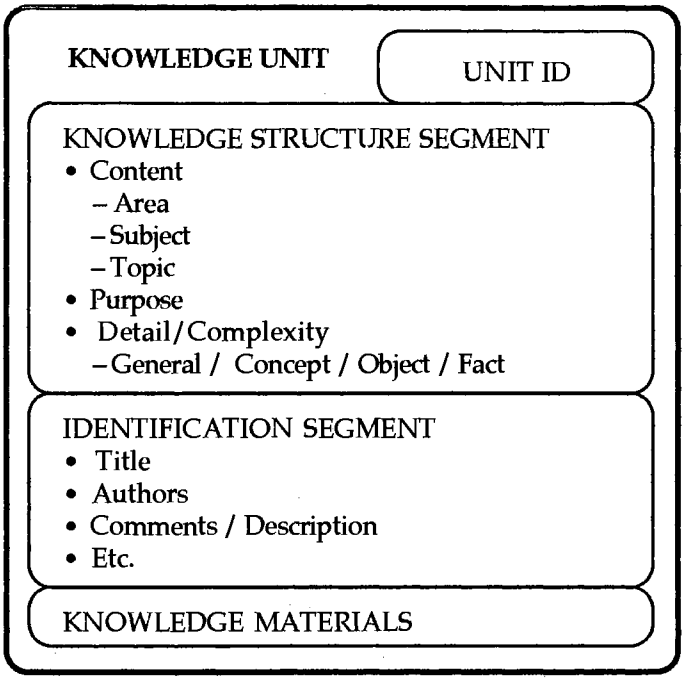


Figure 30. Knowledge Unit

The Knowledge Structure Segment contains the unit's location in the Knowledge Cube (content, purpose, and detail/complexity). This segment can be viewed as a set of attributes which have been derived from the data structure. The Identification Segment contains a more traditional identification used for the knowledge units, such as title, authors, descriptions, etc. The final segment contains the actual knowledge.

4.3.3 Knowledge Insertion

The dynamic nature of the Knowledge Cube allows new knowledge units to be inserted for future retrieval by adapting or extending the existing structure categories. To organize the new knowledge, this insertion process uses the data structure developed in section 4.3.2. The following are the steps in the knowledge insertion process:

1. **Content**

- The application displays an alphabetical list of all content areas which exist in the knowledge base.
    - The user selects the content area which applies to the new unit or enters the name of a new content area.
- The application displays an alphabetical list of all subjects which exist for the selected content area.
    - The user selects the subject which applies to the new unit or enters the name of a new subject.
- The application displays an alphabetical list of all topics which exist in the knowledge base for the selected content area and subject.
    - The user selects the topic which applies to the new unit or enters the name of a new topic.

2. **Purpose**

- The application displays the purpose categories of the knowledge structure.
    - The user selects the purpose category which applies to the new unit.

3. **Detail/Complexity**

- The application displays the four levels of the detail/complexity dimension.
    - The user selects the appropriate detail/complexity level for the new unit.

4. **Unit Identification**

- The application lists the unit's classification in the knowledge structure.
    - The user complete's the unit's Identification Segment.

4.3.4 Knowledge Search and Retrieval

The primary purpose of a knowledge search is to find the appropriate knowledge that is needed to make a decision or solve a problem. However, there are other reasons for searching the application's knowledge base: the knowledge base administrator may want to inventorize the materials contained in it or may want to check for the existence of a particular type of material for inspection. Based on the Knowledge Cube, the automated application should support at least two types of searches. The first type of search navigates through the Knowledge Cube; the second is a direct keyword search.

Navigational Search

A search of the application's knowledge base contents using the Knowledge Cube would take the user into the structure in discrete steps, eventually zeroing in on a particular unit or set of units. To provide true multidimensional access to the search, any of the Knowledge Cube's three dimensions (content, purpose, and detail/complexity) should be available as a starting point for the search. It should be also possible to enhance the search by using any of the other two dimensions, if needed.

A search, then, starts at the highest level of either the content, purpose, or detail/complexity dimension. The user can select any level of a dimension and request to inspect a list of those units which are available for this level. For example, the user can choose to start at the content dimension, select a particular area and subject, and request the list of all units which exist for the selected subject.

However, the search could also involve additional Knowledge Cube dimensions. For example, after selecting a particular subject, the user may choose the purpose dimension, select a particular purpose, and request the list of all units which exist for the

selected subject and purpose. Similarly, the third dimension (detail/complexity) could be chosen to further refine the search.

Whenever a list of units is displayed, the user can retrieve the information about that unit from the database or add it to a list of units which make up a larger knowledge sequence.

Keyword Search

At times, the user may wish to perform a direct keyword search of the application's knowledge base. A keyword search would require the entry of a search criterion for the different dimensions of the Knowledge Cube. The criterion would be compared to the knowledge base attributes and matching occurrences would be included in the application's output. The result of a search, then, would be a listing of those units which match all supplied search criterion. Subsequently, the user can retrieve the information about any of the reported units or add them to a list of units which make up a larger knowledge sequence.

4.3.5 Application Implementation Platform

The Knowledge Cube, as operationalized in the preceding subsections, was instantiated into a prototype application in order to test its feasibility. The platform for this prototype was the Apple Macintosh. The Microsoft FoxPro database management system (DBMS) was used as the application's database and programming environment.

The selection of the Macintosh platform was based both on its availability for this project at both the development and testing sites. The selection of the FoxPro DBMS was based on its availability, the preference of the testing site for this environment, and the

cross-platform compatibility of this environment which would allow for the possible porting of the prototype to the IBM-PC DOS and Windows environments. In addition, the FoxPro DBMS allows for applications to be developed which offer a user-friendly graphic user interface with buttons, pull-down and pop-up menus, and graphic elements.

4.3.6 Application Development

Application development using the FoxPro database management system is centered around the definition of screens. Screen definition is the process of assigning objects (such as input fields, output fields, push-buttons, and pop-up menus) and procedures (such as opening files and performing relational queries) to a screen. Application development, then, is the process of interconnecting screens in a hierarchical manner. The FoxPro DBMS also allows for the definition of pull-down menus (which appear on top of the screen) to further enhance the application's user-interface. However, only minimal use was made of this feature for the current application.

The following steps summarize the application development process.

System Analysis & Design:

- Analysis of the knowledge materials and work practices at Zenger-Miller.
- Construction of a data-structure based on the combination of the Knowledge Cube (see section 4.3.2) and Zenger-Miller's knowledge materials.
- Determination of the five main functions of the application (knowledge entry, reporting, knowledge search & retrieval, knowledge structure description, and quit).

System Construction & Testing:

- Conversion of the data structure into a set of four FoxPro database files.
- Conversion of the knowledge entry and search steps (see sections 4.3.3 and 4.3.4)

into FoxPro screen designs.

- Development of the FoxPro screens for the five main functions of the applications.
- Integrate the five functions by using a main menu for the application.
- Test the application using simulated data.
- Load the Zenger-Miller data into the application's databases.
- Final testing of the application.

FoxPro's application development functions are limited to the area of system construction; they do not provide support for systems analysis and design. Nevertheless, FoxPro's development environment proved to be quite suitable for the building of the Knowledge Cube application. FoxPro's database-definition and screen-development modules enable the rapid application development of a graphical user interface, resulting in an application with easy-to-use screen controls and a polished look. To maintain this polished look, however, FoxPro requires that an application's outputs (screens and reports) be adjusted whenever it is ported to a different computer, even within the Macintosh platform. This turned out to be the only drawback to the use of FoxPro for this project.

The resulting application's data structure, logical design, and outputs are provided in Appendix A.

4.4 Case Study Design

4.4.1 Introduction

The effectiveness and usefulness of the Knowledge Cube and its accompanying automated application was evaluated using a descriptive case study, following Yin's description of the case study method.

The following subsections describe the design of the case study as it was performed at the corporate headquarters of Zenger-Miller, Inc., a managerial training and development firm in San Jose, CA. The subsections cover a brief description of the method, the study's testing objectives, it research components, its experimental design, and its data collection procedures. The results of this study are reported in chapter 5.

4.4.2 The Case Study Method

Yin defines a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used." (Yin, 1984, p. 23) Compared to other research methods, such as laboratory experimentation and surveys, the case study method can typified as a descriptive and qualitative one: it does not rely on the explicit manipulation of experimental subjects, the application of statistical data analysis techniques is not always appropriate or necessary, and it can utilize a large variety of data types, both quantitative and qualitative.

Yin (1984, p. 25) distinguishes three broad types to case study. An explanatory case study can be used to uncover and describe causal linkages too complex to assess using surveys or experiments, and possibly to evaluate competing explanations for a single set of events. A descriptive case study can be used to describe a context or a succession of events, or to illustrate and evaluate, in a journalistic manner, a particular event. Finally, an exploratory case study can be used to investigate an event, the effects or outcomes of which are still unknown.

The case study method has several distinct advantages. Yin asserts that "as a research endeavor, the case study contributes uniquely to our knowledge of individual, organizational, social, and political phenomena," (Yin, 1984, p. 14) and its chief advantage

lies in "its ability to deal with a variety of evidence - documents, artifacts, interviews, and observations." (Yin, 1984, p. 20)

4.4.3 Case Study Appropriateness

Before conducting a case study, the appropriateness of this research method must be assessed. Yin defines a case study as the empirical investigation of "a contemporary phenomenon within its real-life context" in which "the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." (Yin, 1984, p. 23)

The current study meets all three aspects of this definition. The activity of knowledge organization and retrieval is studied as it occurs in a real business setting. Given that the shape and content of much organizational knowledge can be assumed to vary to a substantial degree among organizations, the phenomenon (knowledge organization and retrieval) and the context (the business organization) are not easily separable. And finally, multiple, qualitative sources of evidence are used to assess the processes of knowledge organization and retrieval.

The type of case study performed was exploratory, as the effects or outcomes of the phenomenon under study were unknown before the study took place. (Yin, 1984, p. 25)

The design of the current study can be summed up as an embedded multiple-case design. The multiple-case design stems from the fact that more than a single unit of analysis was employed: in the study, six experimental participants classified and located multiple pieces of knowledge. The case study is embedded in that the overall objective of knowledge organization has been broken down into the activities of classifying and locating and into the criteria of perceived usefulness and effectiveness.

4.4.4 Testing Objectives

The objective of the current study was to examine the use of the Knowledge Cube developed in section 3.7.6 in a practical setting. This use involved (1) the inserting of knowledge into the knowledge structure through a classification and organization process, and (2) the retrieval of knowledge by searching the knowledge structure. The use of the knowledge structure was to be evaluated on the criteria of usefulness as perceived by the subjects using the knowledge structure, and effectiveness as shown by the results of the inserting and retrieval activities.

4.4.5 Case Study Research Components

The following are the five research components of this case study, as based on Yin (1984, pp. 29-35).

- **Study Questions**. How can the Knowledge Cube/application prototype help Zenger-Miller organize its skill units? Is the Knowledge Cube perceived to be either more or less useful than other methods for organizing skill units employed by this company?

- **Proposition**. The Knowledge Cube, when applied to the organization of skill units, facilitates easy and effective retrieval of Zenger-Miller's training materials by its employees.

- **Units of analysis**. A person using the Knowledge Cube/application prototype for the purpose of loading new knowledge or retrieving existing knowledge.

- **Logic Linking the Data to the Propositions.** The observed activities of the people using the Knowledge Cube/application prototype display the expected advantages of usefulness and efficiency. A questionnaire administered following the activities may provide similar indications.

- **Criteria for Interpreting the Findings.** Patterns may emerge from the observed activities and the administered questionnaires which indicate the usefulness and effectiveness of the Knowledge Cube/application prototype. Triangulation of objective results (outcomes of the knowledge organization and retrieval activities) and subjective results (satisfaction analysis questionnaires and researcher observations) can be used to support the found patterns.

4.4.6 Case Study Validity Issues

It is necessary at this point to address the matter of validity as it relates to case study research. Validity, like so many other aspects of case study research, is essentially a qualitative and therefore often subjective matter. In practice, ensuring case study validity requires the careful planning, execution, and documentation of the case study and its results. The following, then, describes how the four types of validity as described by Yin (1984, p. 36) relate to the current case study.

- **Construct Validity.** Based on the recommendations of Yin (1984, pp. 37-38) multiple sources of evidence were gathered during the course of the study to build a chain of evidence. Both objective and subjective indicators of the effectiveness of the Knowledge Cube at Zenger-Miller were gathered to support the conclusions. In addition, a chain of evidence is provided which describes the processes of theory development, data collection, and data analysis. Finally, the portion of the case study report which describes the case study environment was reviewed by one of

the participants in the study.

- **Internal Validity.** Given that the current exploratory study does not attempt to establish a causal relationship, this type of validity need not be established. (Yin, 1984, p. 38).

- **External Validity.** To enhance the generalizability of the case study results, six participants were asked to take part in the study, making this a multiple-case design. In addition, the case study results will be generalized not to other environments, but rather to a broader theory. (Yin, 1984, p. 39)

- **Reliability.** To minimize errors and biases and enhance the repeatability of both the data collection and the data analysis processes, the case study procedures are fully documented. (Yin, 1984, p. 40) The data collection procedures are described in section 4.4.7. The case study instruments and protocols used are provided in appendices B and C. Finally, the results of the case study, the so-called case study database, are provided in chapter 5.

4.4.7 Data Collection Procedures

4.4.7.1 Introduction

The following sections describe the data collection procedures used as well as the sources of the data. A research relationship was established with Zenger-Miller, Inc., a managerial training and development firm headquartered in San Jose, CA. This location was visited twice. The first visit constituted a general orientation of the organization and supplied the necessary information to adapt the Knowledge Cube to fit Zenger-Miller's knowledge materials. The second visit was when the actual case study was performed and

most relevant data was gathered.

4.4.7.2 Establishing the Research Relationship

Initial contacts with Zenger-Miller, Inc., were made by telephone and in writing. The objectives and procedures of the study were explained to the company's Division Director for Research Services, who felt that the study would be of interest to the company. A cooperative research agreement was drawn up, which ensured the confidentiality of the proprietary materials of both the researcher and of Zenger-Miller.

4.4.7.3 Visit 1 - Orientation

The first visit to Zenger-Miller's corporate headquarters took place on 11, 12, and 13 July, 1994. This visit allowed the researcher to become familiar with the company, its organizational structure, its work practices, and its knowledge materials. Moreover, the researcher was able to explain the purpose and procedures of the study to several key people in the organization. Finally, arrangements were made for the second visit during which the actual knowledge organization and retrieval study would take place.

The following sources of data were used during this visit:

- **Zenger-Miller public documentation:** Several brochures describing the organization and the services it offers; the Times Mirror 1993 Annual Report (As described in section 4.5, Zenger-Miller, Inc., is a subsidiary of Times Mirror.); brochures containing a general description of each of Zenger-Miller's training programs.

- **Zenger-Miller proprietary documentation:** Detailed descriptions of the skill units which make up Zenger-Miller's training programs. These descriptions not only explain the contents of the skill units, but also the general manner in which they are to be taught, the appropriate audience for the unit, and the estimated annual number of students for each unit. Much of the information contained in these descriptions was used to design and fill the database of the application prototype.

- **Zenger-Miller knowledge materials:** The researcher viewed the materials for several skill units, which included facilitator's guides, the participants' workbooks, and instructional videotapes.

- **Interviews:** Three Zenger-Miller employees were interviewed during this visit. The organization's Division Director of Research Services provided an introduction to the organization and explained the general make-up of Zenger-Miller training programs. The Senior Project Manager, who is in charge of new development, provided an overview of the development process, gave some background to the types of training materials used, and explained the nature of Zenger-Miller's Designed Systems. The person in charge of Special Projects for Marketing described the company's recent effort to combine skill units into accredited courses for which participants can obtain college credit. Much of the information gathered in this effort could also be used by consultants to create Designed Systems and could therefore be included in the application prototype's database.

The first visit's data collection procedures resulted in the following:

- The description of the organization and its activities (see section 4.5).
- The instantiation of the general knowledge structure for Zenger-Miller's knowledge materials as described in section 4.5.6.

- The creation of a prototype application for the organization and location of knowledge units based on Zenger-Miller's knowledge materials - the so-called skill units - and work practices. This application is described in appendix A.

4.4.7.4 Visit 2 - Performing the Study

The second visit to Zenger-Miller's corporate headquarters took place on 16, 17, 18, and 19 August, 1994. Prior to this visit, six participants representing different functions of the company had been asked by the organization's research director to take part in the study. Each participant was involved in two sessions. The research instruments and protocols used during this visit are provided in Appendices B and C.

The first session started with an introduction to the study, the knowledge structure, the application, and the task. Subsequently, the participant was asked to organize five distinct pieces of training called skill units using the application prototype and a description of each skill unit. Each participant organized the same five skill units. Finally, the participant was asked to fill out a satisfaction analysis questionnaire regarding the task, the application prototype, and the knowledge structure.

The second session started with with an abbreviated introduction to the knowledge structure, the application, and the task. Subsequently, the participant was asked to locate several skill units using the application prototype and four short case problems. Each participant received the same four case problems. Finally, the participant was asked to fill out a satisfaction analysis questionnaire regarding the task, the application prototype, and the knowledge structure.

Two aspects of the Knowledge Cube were key to the design of the case study protocol. The first, more objective, aspect is comprised of the actual results: how the skill

units were organized by the participants during the first activity, and which skill units the participants selected during the second activity. The second, more subjective, aspect relates to the experience: how the participants perceived their use of the computer application and the Knowledge Cube. Both these aspects are important in the evaluation of both the application and the Knowledge Cube, and the gathered data reflect the attempt to capture both aspects. The following, then, are the sources of data used during this portion of the study:

- **Observation of organizing task:** Participants were observed as they evaluated the skill units and the existing content-dimension descriptions, as well as the other dimensions of the Knowledge Cube. Participants then selected the appropriate content-dimension descriptions or added new content-dimension descriptions, selected purpose and audience categories, and entered the skill-unit descriptions. The observed activities were logged by the researcher.

- **Knowledge entry results:** The knowledge structure classification as determined by the participants for the newly organized skill units, recorded by the researcher.

- **Debriefing after the organizing task:** Participants described their experiences with the Knowledge Cube, the task, and the application using a satisfaction analysis questionnaire. In addition, other comments made regarding these items were noted.

- **Observation of retrieval task:** Participants were observed as they interpreted the case problems and determined training needs. They selected database entry points for searching using the application prototype. Participants then selected the appropriate skill units. The observed activities were logged by the researcher.

- **Knowledge retrieval results:** The selected skill units for each of the case problems as determined by the participants, recorded by the researcher.

- **Debriefing after the retrieval task:** Participants described their experiences with the Knowledge Cube, the task, and the application using a satisfaction analysis questionnaire. In addition, other comments made regarding these items were noted.

The results and subsequent analysis of this portion of the study are described in chapter 5.

4.5 Case Study Environment & Knowledge Materials

4.5.1 Introduction

The case study took place at Zenger-Miller's corporate headquarters in San Jose, CA. The following sections briefly describe this company's origins, structure, and main product lines.

4.5.2 History of Zenger-Miller, Inc.

Zenger-Miller was founded in 1977 by John H. Zenger and Dale Miller as a regional management consulting firm in Northern California. Soon the company expanded nationwide and refocused its efforts on managerial training and development. Since its founding, the company has grown into a multinational developer of training and development programs and services which teach interpersonal and supervisory skills. (Gordon, 1994) In the mean time, INC. magazine has listed Zenger-Miller twice on its list of the fastest-growing companies in the U.S., and in 1985 the company was selected by the

International Customer Service Association as one of the two best customer-service companies in the country. (In Practice, 1989)

In 1989, Zenger-Miller was acquired by the publishing and information services conglomerate Times Mirror Co., where it became part of the conglomerate's Book, Magazine, and Other Publishing division. This division also includes two other training and development companies, Kaset International and Learning International. While retaining a large measure of independence, the three training and development companies cooperate as the Times Mirror Training Group - particularly in the international market. The combined efforts of these three companies make Times Mirror the world's largest provider of professional training. (Times Mirror 1993 Annual Report, p. 17; In Practice, 1989)

Recently Zenger-Miller acquired the Canadian consulting company Achieve, which has specialized in the development and delivery of executive-level programs. Consequently the company's product line expanded to include an Executive Retreat and executive programs which focus on the issues of service and quality. In late 1994, the company's name was officially changed to "Zenger Miller."

At this time, the company serves more than 3000 public and private sector clients, including half of the Fortune 500. (Gordon, 1994; In Practice, 1989) Its international division offers training programs in more than 10 languages and 50 countries.

4.5.3 Organizational Structure

Zenger-Miller does not maintain an organizational chart of its San Jose corporate headquarters. Two reasons are given for this: first, the acquisition of Zenger-Miller by Times Mirror is still causing changes in the organizational structure. Second, the

organization values its flexibility and encourages this by not creating a fixed role pattern. Nevertheless, the following functions can be discerned at the San Jose location:

- **Administration** - this includes the company's management, finance, accounting, and human resources functions.
- **Production** - the following functions are directly product-related:
  - **Product Development**: a cross-functional team which guides the research, development, production, launching, and maintenance of products and services. This is the function which produces the most tangible of Zenger-Miller's products, the facilitator's guides, participants' workbooks, and video tapes.
  - **Research**: this function provides support for both the product development and marketing functions.
  - **International**: this function provides support for the translation and/or adaptation of Zenger-Miller products for foreign markets.
- **Selling** - the following functions relate to sales and marketing:
  - **Marketing** - provides sales materials such as brochures and advertising layouts, and is involved in the identification, launching, and selling of new products.
  - **Customer Services** - takes and enters customer orders.
  - **Field Support** - assists salespeople and consultants with information about Zenger-Miller's clients and their training needs.
- **Operational Support** - this includes office services (which maintains the San Jose office), information services (which maintains telephones and other equipment), and operations (photocopying, packaging, and shipping).

4.5.4 Zenger-Miller Products

While it is known as a managerial training and development company, Zenger-Miller usually does not deliver the training it develops. Rather, it develops training programs and - if needed - trains and certifies the trainers or facilitators who deliver the training on the clients' sites.

Zenger-Miller's products include Quest (which focuses on quality and skills training), FrontLine Leadership (which aims at managerial skills), Problem Solving (also contained in FrontLine Leadership, this program focuses on individual and group problem solving), Working (which focuses on developing the interaction skills of non-supervisory employees), and Team Effectiveness, Team Leadership, and Working for Self-Directed Work-Teams (which focus on developing the skills needed to effectively work in teams).

Most training programs consist of a set of skill units. Each skill unit is a distinct piece of training which takes from three to five hours to complete and essentially contains three types of training materials:

- A facilitator's guide which describes in great detail the training objectives, how the training should be delivered, what flip charts and overhead transparencies need to be prepared, and how the exercises should be conducted.
- A participant's workbook which describes the lessons and contains instructions and forms for exercises.
- A video tape which contains models, situations, or cases which focus on the topic at hand and provide a starting point for discussion.

Sample descriptions of skill units are provided in Appendix C.

4.5.5 Zenger-Miller's Knowledge Materials

Zenger-Miller originally sold only complete training program to its clients. However, in order to provide customized training solutions for its clients, Zenger-Miller introduced the concept of Designed Systems. A Designed System is put together by Zenger-Miller consultants and salespeople for a single client and may contain skill units from several programs. As such, a Designed System offers a customized solution to fit a client's training needs. However, this does require the consultants and salespeople to have substantial knowledge of the content of the skill units and the issues they address. An alternative to the consultants and salespeople being highly knowledgeable about the skill units' contents would be to provide them with a tool to retrieve such knowledge based on perceived training needs.

It was thought that the combination of the Knowledge Cube developed in section 3.7.6 and the automated application described in appendix A could result in a tool which would allow Zenger-Miller consultants to access the skill units in an effective manner. For this purpose, the Knowledge Cube was instantiated to fit Zenger-Miller's business environment and an application was developed which automated the use of the Knowledge Cube at Zenger-Miller.

4.5.6 Knowledge Cube Dimensions at Zenger-Miller

The application of the Knowledge Cube at Zenger-Miller required it to be instantiated and customized to fit Zenger-Miller's knowledge materials and procedures. The following, then, are the three Knowledge Cube dimensions as they were defined for use at Zenger-Miller.

Content

The original three levels of this dimension, which are listed below, can be directly applied to the particular areas for which Zenger-Miller has developed training programs.

- **Area:** General disciplines for which knowledge exists. Areas can be defined broadly.
- **Subject:** Within an area, different subjects may be identified which cover a somewhat more specific discipline or specialty.
- **Topic:** A specific concept within a given subject or area of expertise.

Purpose

Based on discussions with key Zenger-Miller associates and a review of the company's business objectives and practices, the following five purpose-categories can be used to describe the range of training materials developed by Zenger-Miller:

- **Enhance Quality** - this relates to the issues of customer orientation, product quality, and process quality.
- **Enhance Innovation** - this relates to the issues of organizational flexibility and adaptability, and the enhancement of organizational culture.
- **Enhance Organizational Productivity** - this relates to the objectives of overall organizational efficiency, business process re-engineering, downsizing, delayering, and overall organizational competitiveness.
- **Enhance Individual Performance** - this relates to the issues of employee performance and empowerment, managerial performance, interpersonal skills, and communication skills.

- **Enhance Group Performance** - this relates to the issues of team work, team leadership, and team interactions and intercommunications.

Detail/Complexity – Audience

Applying the Detail/Complexity dimension to the knowledge materials at Zenger-Miller is an ambiguous task. The skill units cannot easily be differentiated by their level of detail - indeed the materials covered in each individual skill unit often address several levels of detail. In addition, the skill units are not easily differentiated by complexity - most skill units have little or no prerequisite knowledge required and would all appear to fall into a single complexity-level. However, a finer distinction can be made when taking into account the prerequisite work experience required by some of the skill units. Based on the skill unit descriptions, it becomes possible to distinguish different audience types for the skill units as distinguished by Zenger-Miller. The following audience types are identified in the Zenger-Miller training program descriptions:

- **Executives** - top-level people in the organization, who (among other things) deal with the organization's long-term strategy.
- **Managers / Supervisors** - People in management or supervisory positions who are generally overseeing production-level or administrative work.
- **Non-Supervisory Employees** - individual contributors performing production-level or administrative work.
- **Team Leaders** - people leading permanent or temporary work groups, such as multidisciplinary teams.
- **Team Participants / Members** - people participating in permanent or temporary work groups.
- **Multiple Audiences** - the skill unit is appropriate to more than one of the above audiences.

The Audience dimension fits the original Detail/Complexity dimension as it combines both elements of content and purpose. The type of audience for which a skill unit was developed will directly affect its content (such as leadership skills vs. participative skills) as well as its purpose (e.g., to develop individual or organizational aspects).

These customized Knowledge Cube dimensions were incorporated into the application development effort, and are therefore clearly reflected in the resulting application that was used for the knowledge organization and retrieval tasks during the second visit to Zenger-Miller (see also the application description in Appendix A). The data collection results and the subsequent data analysis procedures (see chapter 5) do also refer to these customized Knowledge Cube dimensions.

CHAPTER V

CASE STUDY RESULTS AND ANALYSIS

5.1 Introduction

This section presents the results of the case study performed at Zenger-Miller, Inc., on August 16 through 19, 1994. In this section, the results and subsequent analysis are organized as follows:

- Section 5.2 briefly describes the background of the six participants in the study.
- Section 5.3 describes the results and analysis of the knowledge organization activity, in which the participants entered new knowledge into the Knowledge Cube.
- Section 5.4 describes the results and analysis of the knowledge retrieval activity, in which the participants selected knowledge from the Knowledge Cube based on a set of four case problems.
- Section 5.5 elaborates on a substantial finding in this study: the potential need for multiple classification of knowledge.
- Section 5.6 relates the Knowledge Cube implementation and the study's results back to the knowledge structure organizing principles (see section 3.7.3).

The conclusions drawn from the case study results are contained in chapter 6.

5.2 Participants

Six participants, representing different functions of the organization, were recruited by Zenger-Miller's research director to be part of the study. These participants all deal with the skill units as part of their job responsibilities. However, the intensity of their use of and

expertise on the skill units differ. Three of the participants, because of the nature of their jobs, were highly familiar with all of Zenger-Miller's skill units and are henceforth designated as content experts. The other three participants, the non-content experts, were not highly familiar with all of the skill units. The following briefly describes the participants' functions in the organization:

Participant 1 – Field Audience Manager, a content expert who acts as a liaison between the organization's headquarters and its field sales force.

Participant 2 – Senior Project Manager, in charge of product development.

Participant 3 – Human Resources Representative, consults and performs training.

Participant 4 – Division Director of Research Services, heads research for marketing and product development functions.

Participant 5 – Account Manager, a content expert who consults and educates clients on training programs.

Participant 6 – Senior Consultant, a content expert who consults, recommends training, and trains facilitators.

5.3 The Knowledge Organization Activity

5.3.1 Starting Knowledge Base

At the start of the knowledge organization activity, the participants were provided with a knowledge base which contained 61 skill units. Each skill unit had been classified by the researcher according to content, purpose, and audience. These classifications were closely based on Zenger-Miller's skill unit descriptions. The skill units which the participants were to classify, as well as several very similar ones, were not part of the knowledge base.

Table II lists, in alphabetical and hierarchical order, the available content categories which the participants examined and used as part of the knowledge organization activity. They were able to use existing categories or add their own to the knowledge base.

AREAS	SUBJECTS	TOPICS
Employee Development	Communication Skills	Communicating with Superiors
		General Skills
		Working with Others
	Productive Work Skills	Empowerment
		Working with Others
Managerial Development	Developing the Organization	Change & Innovation
	Interpersonal Skills	Basic Skills
		Organizational Relationships
	Management Support Role	Supporting Groups
		Supporting Individuals
	Problem Solving	Problem Solving Fundamentals
Teamwork	Team Leadership	Change & Innovation
		Facilitating Teamwork
		Team Building
		Team Goals
	Team Participation	Individual Contributions
		Motivation for Teams
		Working as a Team
Total Quality Management	Committing to Quality	Maintaining Quality
		Preparing for Quality
	Performing Quality	Quality-focused Work

Table II. Content Categories at the Start of the Organization Activity

5.3.2 Knowledge Organization Results

The six participants in the study were asked to classify and enter five skill units based on their descriptions as shown in Appendix C. Table III shows the classification results for the first skill unit.

	Participant 1	Participant 2
AREA	Teamwork	Teamwork
SUBJECT	Team Leadership	Team Leadership
TOPIC	Facilitating Teamwork	Team Building
PURPOSE	Individual Performance	Group Performance
AUDIENCE	Team Participants/Members	Managers/Supervisors
	Participant 3	**Participant 4**
AREA	Teamwork	Teamwork
SUBJECT	Team Leadership	Team Leadership
TOPIC	Team Goals	Team Building
PURPOSE	Group Performance	Individual Performance
AUDIENCE	Team Leaders	Team Leaders
	Participant 5	**Participant 6**
AREA	Managerial Development	Managerial Development & Leading Teams
SUBJECT	Developing the Organization	Management Support & Team Leadership
TOPIC	Change & Innovation	Facilitating Teamwork
PURPOSE	Organizational Productivity	Organizational Productivity
AUDIENCE	Managers/Supervisors	Managers/Supervisors

Table III. Skill Unit 1 - Clarifying Team Roles and Responsibilities

The participants agreed highly on the content of this skill unit being about some form of team leadership. However, agreement on purpose and audience was rather low.

Table IV shows the classification results for the second skill unit.

	Participant 1	Participant 2
AREA	Managerial Development	Managerial Development
SUBJECT	Management Support Role	Developing the Organization
TOPIC	Supporting Groups	Change & Innovation
PURPOSE	Innovation	Innovation
AUDIENCE	Multiple Audiences	Managers/Supervisors
	Participant 3	**Participant 4**
AREA	Employee Development	Managerial/Supervisory Development
SUBJECT	Productive Work Skills	Developing the Organization
TOPIC	Creativity and Risk-Taking	Change & Innovation
PURPOSE	Innovation	Innovation
AUDIENCE	Managers/Supervisors	Managers/Supervisors
	Participant 5	**Participant 6**
AREA	Managerial Development	Managerial Development & Leading Teams
SUBJECT	Problem Solving	Management Support & Team Leadership
TOPIC	Problem Solving Fundamentals	Change & Innovation
PURPOSE	Innovation	Innovation
AUDIENCE	Managers/Supervisors	Multiple Audiences

Table IV. Skill Unit 2 - Fostering Improvement Through Innovation I and II

The participants agreed mostly that this skill unit was about the Area of managerial development, but significantly disagreed on its Subject and Topic. They all agreed on the purpose (innovation) and mostly felt his unit was intended for managers and supervisors.

Table V shows the classification results for the third skill unit.

	Participant 1	**Participant 2**
AREA	Employee Development	Teamwork
SUBJECT	Communication Skills	Team Participation
TOPIC	General Skills	Working as a Team
PURPOSE	Individual Performance	Group Performance
AUDIENCE	Multiple Audiences	Non-Supervisory Employees
	Participant 3	**Participant 4**
AREA	Employee Development	Employee Development
SUBJECT	Communication Skills	Communication Skills
TOPIC	Working with Others	Working with Others
PURPOSE	Organizational Productivity	Individual Performance
AUDIENCE	Non-Supervisory Employees	Non-Supervisory Employees
	Participant 5	**Participant 6**
AREA	Employee Development	Employee Development
SUBJECT	Communication Skills	Communication Skills
TOPIC	Working with Others	Working with Others
PURPOSE	Organizational Productivity	Individual Performance
AUDIENCE	Non-Supervisory Employees	Non-Supervisory Employees

Table V. Skill Unit 3 - Resolving Issues with Others

The participants greatly agreed on this skill unit's content (employee development, communication skills, working with others) and on its audience (non-supervisory employees), but far less on its purpose.

Table VI shows the classification results for the fourth skill unit.

	Participant 1	**Participant 2**
AREA	Employee Development	Total Quality Management
SUBJECT	Communication Skills	Performing Quality
TOPIC	Working with Others	Quality-Focused Work
PURPOSE	Organizational Productivity	Quality
AUDIENCE	Multiple Audiences	Multiple Audiences

Table VI. Skill Unit 4 - Clarifying Customer Expectations

	Participant 3	Participant 4
AREA	Total Quality Management	Total Quality Management
SUBJECT	Performing Quality	Performing Quality
TOPIC	Quality-Focused Work	Quality-Focused Work
PURPOSE	Quality	Quality
AUDIENCE	Multiple Audiences	Multiple Audiences
	Participant 5	**Participant 6**
AREA	Total Quality Management	Total Quality Management
SUBJECT	Performing Quality	Performing Quality
TOPIC	Quality-Focused Work	Quality-Focused Work
PURPOSE	Quality	Quality
AUDIENCE	Multiple Audiences	Multiple Audiences

Table VI. Skill Unit 4 - Clarifying Customer Expectations (Continued)

Of the five skill units, this one had the highest level of agreement among the participants. Five out of six participants agreed completely on all three dimensions.

Table VII shows the classification results for the fifth skill unit.

	Participant 1	Participant 2
AREA	Managerial Development	Teamwork
SUBJECT	Management Support Role	Team Leadership
TOPIC	Supporting Groups	Facilitating Teamwork
PURPOSE	Group Performance	Group Performance
AUDIENCE	Managers/Supervisors	Multiple Audiences
	Participant 3	**Participant 4**
AREA	Total Quality Management	Managerial/Supervisory Development
SUBJECT	Performing Quality	Developing the Organization
TOPIC	Quality-Focused Work	Change & Innovation
PURPOSE	Quality	Innovation
AUDIENCE	Managers/Supervisors	Managers/Supervisors
	Participant 5	**Participant 6**
AREA	Managerial Development	Managerial Development & Leading Teams
SUBJECT	Management Support Role	Management Support & Team Leadership
TOPIC	Supporting Individuals	Facilitating Teamwork
PURPOSE	Organizational Productivity	Organizational Productivity
AUDIENCE	Managers/Supervisors	Multiple Audiences

Table VII. Skill Unit 5 - Leading Problem Solving Sessions

Of the five skill units in this activity, this unit appears to have the lowest level of agreement among the participants on content, purpose, and audience.

5.3.3 Inter-Rater Agreement for the Knowledge Organization Activity

In order to quantify the level of agreement among the study's participants for the knowledge organization activity, coefficient Kappa (Cohen, 1960) was computed for the Area-level of Content, for Purpose, and for Audience. (Kappa-values for Content-Subject and Content-Topic were not included as the hierarchical nature of this organization scheme does not match coefficient Kappa's assumptions.) The computed Kappa-values are shown in Table VIII.

Variable	**k**
Content-Area	.2815
Purpose	.3130
Audience	.4973

Table VIII. Kappa-values for Knowledge Organization Activity

Kappa is defined as a chance-corrected measure of agreement among raters for classification using a nominal variable. The raters are assumed to independently classify each of a sample of units into one of a set of mutually exclusive and exhaustive categories. (Fleiss et al, 1979) The value of Kappa ranges from -1 (a poorer than chance level of agreement) to 0 (agreement similar to that which could be expected to occur by chance) to +1 (agreement far exceeding that which could be expected to occur by chance). (Fleiss, 1971; Fleiss et al, 1979)

Four points must be made when interpreting the Kappa-values:

- Fleiss (1971; 1979) does not provide extensive guidelines for evaluating or interpreting the found Kappa-values, nor does Cohen (1960) who originally defined

the measure. Interpretation, then, is mainly guided by considering the found level agreement as it differs from chance agreement.

- Fleiss (1979) provides a standard-error formula for coefficient Kappa but notes that this formula is valid only when a large number of units is being classified. Given that only five units were classified in this study, the standard-error was not computed.

- Based on some participants' comments, Fleiss' assumption that the classification categories be mutually exclusive may have been violated. Particularly the Audience-categories were not always considered to be completely mutually exclusive. Since the participants were asked to select the most appropriate Audience-category, it is not known how this would affect the Kappa statistic.

- In computing the Kappa-values, Content-Area was taken to have five categories (Employee Development, Managerial Development, Teamwork, Total Quality Management, and New), which match the available categories at the start of the organization task. Purpose and Audience were taken to have the provided sets of five and six categories respectively.

The computed Kappa-values indicate that the results of knowledge organization for Content and Purpose are only slightly higher than chance agreement. This would suggest that despite the fixed contents of the skill units, different associates view these skill units from a variety of viewpoints. This may be due to the different ways in which the associates work with the skill-units - e.g. as a developer, trainer, or sales-person.

The Kappa-value for the Audience-variable appears to display a relatively high level of agreement among the raters. However, given that one of the five skill units found the

participants in perfect agreement on the default-category of Multiple Audiences, which might have been interpreted slightly differently by each of the participants, this high Kappa-value may be somewhat misleading.

5.3.4 Satisfaction Analysis Results

After completing the knowledge organization activity, the participants were asked to fill out a questionnaire about their experience with the computer application, the Knowledge Cube, and the task they had just performed. The questions were to be answered on a seven-point Likert-type scale. In addition, they were asked to write down additional comments on how to improve the application and the Knowledge Cube.

The seven-point Likert-type scale is shown in figure 31. The scoring used in this section was performed as follows: the value of one through seven were assigned to the responses, with one being assigned to "completely agree" and seven being assigned to "completely disagree." The scores were then averaged for the six participants. The lower the average score, the more positive the participants felt about the statement responded to.

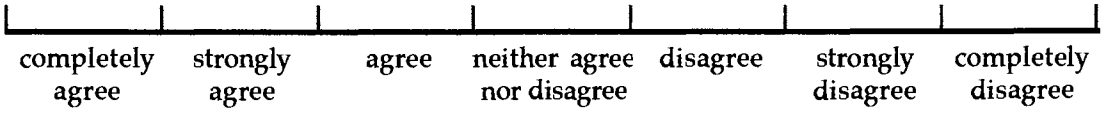


Figure 31. Questionnaire Likert-type Scale.

Table IX lists the questions on the satisfaction analysis questionnaire. For each question the distribution of the individual responses is shown (E designates a content expert, N designates a non-content expert), as well as the average score.

KNOWLEDGE ORGANIZATION SATISFACTION ANALYSIS ITEM	completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree	mean
The FoxPro Application								
1. The computer-application was easy to use.		E E E	N N N					2.50
2. The help-screens provided by the application were useful and informative.			N	E E E N N				3.83
3. It was clear what types of input the application required.	E	E N N	E N					2.17
4. The reports generated by the application were useful.		E E N	N	E N				2.83
5. The application's screen-layouts were clear.	N	E E	E N N					2.33
The Knowledge Structure								
1. The Knowledge Structure appears to be a useful method for organizing skill units.		E N	E N	N	E			3.17
2. The Knowledge Structure appears to be a clear method for organizing skill units.		E N N	E N		E			2.83
3. The Knowledge Structure appears to be a sensible method for organizing skill units.		E N N	N	E	E			3.17

Table IX. Knowledge Organization Satisfaction Analysis Results.

KNOWLEDGE ORGANIZATION SATISFACTION ANALYSIS ITEM	completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree	mean
4. The Knowledge Structure appears to be a complete method for organizing skill units..			E E N		N N		E	4.33
5. The 3-level content-dimensions is useful when organizing skill units.		E E N	N	E N				2.83
6. Having a purpose-aspect is useful when organizing skill units.	E N	N	E E	N				2.33
7. The 6-level audience dimension is useful when organizing skill units.	N	E E	E N	N				2.50
The Task								
1. It was quite easy to determine how to classify each skill unit.		N	E N N		E	E		3.50
2. Each skill unit fit neatly into a single classification.			N		E E N	N	E	5.17
3. I felt quite comfortable classifying the skill units.			E N N N		E E			3.67
4. I would use this application again for the task of classifying skill units.		N	E N N		E E			3.50

Table IX. Knowledge Organization Satisfaction Analysis Results. (Continued)

Responses on the Likert-type scale questions in the Application and Knowledge Structure sections provided no clear distinction between content experts and non-content experts. In the Task section, however, the non-content experts tended to be more positive in their responses than the content experts.

The following are the responses to the two open-ended questions on the satisfaction analysis questionnaire.

The FoxPro Application – How might this application be improved?

- Wrap-around text feature for type-in boxes.
- Tab function to move you from one screen to another.
- Default entries for common information (as "non required").
- Differentiate between help buttons and other buttons.
- Allow for multiple purposes, audiences, etc.
- On continuing screens allow the tab key to send to the next screen and not back to top of current page. (This may not be logistically possible.)
- A database (table) that could be based on ZM-title that would fill in the blanks for PONSI-title, prereq, etc - this was repetitive and could be automated.
- Make sure that instructor type field can be entered as with all other fields.
- Either "on the screen" or "in a manual" you need to explain how to move from field to field - by using the tab key.
- Larger type, backspace.

The Knowledge Structure – How might this knowledge structure be improved?

- Avoid overlapping audiences - i.e., "team members" and "non-supervisory employees."
- Two levels of content hierarchy would be more practical for non-content experts.
- More purposes would be useful.

- There are many ways to look at the knowledge of a unit - from the standpoint of the audience for the training session or the ultimate audience of the new skill (i.e. manager in session learns a new skill, but will ultimately target individual contributor). For consistency, it should be decided what viewpoint to take prior to entering data.
- I cannot answer the useful questions until I try to retrieve the info.
- You could add a fourth dimension of delivery method.
- Don't know at this point - need to work with data.
- Choosing more than one audience.

5.3.5 Additional Participant Comments and Researcher Observations

Time: All participants required substantially less time for classifying the latter skill units than they did for the first ones. This mainly appeared to be a result of increasing familiarity with the application's interface. The average time needed to perform the task was 25.83 minutes (standard deviation = 4.17). Differences between the content experts and the non-content experts in time needed to complete the task were not obvious. The content experts did not spend much time reading the skill unit descriptions but did spend substantial time debating how to categorize each skill unit since they have in the past approached these skill units from various perspectives. The non-content experts spent considerable time reading the skill unit descriptions and determining a classification based on that.

Application: To most participants, the Knowledge Cube itself became almost invisible. Instead, they focused their attention on the application, its functions, and its purpose. They saw possibilities of the application as sales or marketing tool because of its automated access to the skill units. Some participants already envisioned some possible extensions to the application to enhance the application

for sales and field representatives' needs. However, one participant closely connected to the sales function warned against using the application in front of a customer; it would diminish the customer's sense of the value-added that sales-people and consultants bring to the process.

Knowledge Cube: Several participants felt that some of the purpose and audience categories overlapped and that it would be better if some skill units could receive multiple classifications (e.g. "managers" overlapped several times with "team leaders" and "non-supervisory employees" overlapped several times with "team members/participants"). When the participants felt that content-categories overlapped, they participants were encouraged to define their own content-categories.

Task: Several participants felt it handy to have the printed list of available content categories (which is one of the application's reports) available when classifying new skill units. This allowed them to scan the available categories and in addition helped them define new categories. For example, one participant created a new Area-category, but used existing categories to fill in the new Area's Subject and Topic levels.

5.3.6 Analysis of Knowledge Organization Activity Results

The analysis of qualitative data relies greatly on the manual evaluation of results and the identification of patterns. (Miles & Huberman, 1994, p. 246) Examination of the results of both the knowledge organization and knowledge retrieval activity show three issues dominating the data collection results: the effectiveness of the Knowledge Cube, the differing expertise levels of the study's participants, and the possibility of the multiple classification of knowledge. How the knowledge organization activity results relate to

these three issues is detailed in the following subsections.

Knowledge Cube Effectiveness

As mentioned in the previous section, the verbal comments of the study's participants tended to address the Knowledge Cube's vehicle, the automated application, rather than the Knowledge Cube itself. However, on the knowledge organization satisfaction analysis items which specifically addressed the use and value of the Knowledge Cube, the participants responded positively, particularly on its clarity. Moreover, they regarded the three Knowledge Cube dimensions (content, purpose, and audience) as quite useful.

It was clear that the flexibility of the Knowledge Cube plays an important role in this positive perception. The Knowledge Cube was flexible enough to support the different approaches and points-of-view of the various participants. For instance, the knowledge organization results display a low to moderate level of agreement among the participants. A visual inspection of the classifications of each of the five skill units as well as the computed Kappa-values indicate as much. However, a reasonable level of agreement can be found on a higher level. The general disciplines in which the skill units are organized show reasonable levels of agreement. Thus it appears that the Knowledge Cube does not necessarily enforce a particular point-of-view of the pieces knowledge it contains. Rather, within the boundaries of a general context, the Knowledge Cube allows people to bring their own preferences and perspectives, as well as their own interpretation of the knowledge itself, to their usage of the knowledge structure. Consequently, the participants were able to successfully organize knowledge units according to their own point-of-view.

Participant Expertise Levels

In the course of the knowledge organization activity, the difference between those participants highly familiar with all of the skill units (the content experts) and those participants not very familiar with all skill units (the non-content experts) became quickly apparent. Differences between these two groups appear both in how they used the Knowledge Cube and in how they evaluated its usefulness.

When using the Knowledge Cube application, the content experts rarely took the time to read the skill unit descriptions. Rather, they tended to classify the skill units based on their existing knowledge as inferred from the title of a given skill unit. To this they would bring not only their knowledge about the skill unit per sé, but also their experience about how the unit had been applied in the past. The problem for the content experts, then, became how to fit the skill unit as they knew it into a single classification.

The non-content experts, on the other hand, relied almost fully on the skill unit description, from which they tried to infer its classification. The problem for the non-content experts became the determination of what the skill unit was about and for what purpose and audience it was intended, something which the content experts did not need to do.

Moreover, during the knowledge organization activity, the non-content experts stuck closer to the provided content dimension categories than the content experts. Of the nine times in which new content categories were added to the Knowledge Cube by the participants, only two of those can be attributed to a single non-content expert, while the other seven can be attributed to two of the content experts.

Differences in how the content and non-content experts evaluated the Knowledge Cube are evident in the results of the satisfaction analysis questionnaire. Although the small number of subjects (six) prohibits any statistical inferences, a manual examination of the participants' responses shows that the non-content experts were more positive about the Knowledge Cube as a knowledge organization structure. Following the knowledge organization activity, the non-content experts responded more positively than the content experts on the questions relating to the usefulness, clarity, and sensibility of the Knowledge Cube.

Multiple Classification of Knowledge

Allowing for the multiple classification of knowledge - which permits knowledge to be classified into more than a single category - was mentioned by all of the study's participant during the knowledge organization activity. Given the holistic nature of knowledge , it is not surprising that a piece of knowledge such as a skill unit (which, itself, is made up of many smaller pieces of knowledge) can be perceived in several ways, from different points of view, or from the perspective of different organizational roles. Consequently, the multiple classification of pieces of knowledge within the knowledge structure appears to be a natural solution to the classification problem. The knowledge organization activity results support the notion of multiple classification in the following ways.

- Most participants commented on either overlapping categories or wanting to classify a skill unit in more than one category. For example, the audience categories of "non-supervisory employees" and "managers/supervisors" were said to overlap with the categories of "team participants/members" and "team leaders," respectively.

- In categorizing knowledge according to content, the participants defined four new categories: (1) **Managerial Development & Leading Teams**, (2) **Management Support & Team Leadership**, (3) **Managerial/Supervisory Development**, and (4) **Creativity and Risk-Taking**. Each of these new categories is actually a set of two categories. The participants who created these categories actually attempted a form of multiple classification.

- The relatively low Kappa-values for inter-rater agreement indicate that different people are likely to organize a single piece of knowledge in different ways. Given the different perspectives of people, it is useless to argue about a single correct or incorrect way of classifying knowledge.

- The participants' responses to the knowledge organization satisfaction analysis item "Each skill unit fit neatly into a single classification." resulted in the most negative response of all the items, averaging at 5.17. Clearly the participants disagreed with this item.

The implications of the multiple classification of knowledge will be further explored in sections 5.4.5 and 5.5.

5.4 The Knowledge Retrieval Activity

5.4.1 Starting Knowledge Base

At the start of the knowledge retrieval activity, the participants were provided with a knowledge base which contained 69 skill units which had been classified and entered by the researcher. The fact that the skill units were classified by the researcher poses a significant constraint on the study, given that content experts would likely have classified

the skill units differently. However, in actual usage this would not be problematic as the skill units would be initially classified by content experts at the site.

Table X lists, in alphabetical and hierarchical order, the available content categories which the participants were able to examine and use as part of the knowledge retrieval activity.

AREAS	SUBJECTS	TOPICS
Employee Development	Communication Skills	Communicating with Superiors
		General Skills
		Working with Others
	Productive Work Skills	Empowerment
		Working with Others
Managerial Development	Developing the Organization	Change & Innovation
	Interpersonal Skills	Basic Skills
		Organizational Relationships
	Management Support Role	Supporting Groups
		Supporting Individuals
	Problem Solving	Problem Solving Fundamentals
		Problem Solving by Groups
Teamwork	Team Leadership	Change & Innovation
		Facilitating Teamwork
		Team Building
		Team Goals
	Team Participation	Individual Contributions
		Motivation for Teams
		Working as a Team
Total Quality Management	Committing to Quality	Maintaining Quality
		Preparing for Quality
	Performing Quality	Quality to the Customer
		Quality-focused Work

Table X. Content Categories at the Start of the Retrieval Activity

5.4.2 Knowledge Retrieval Results

The six participants in the study were asked to use the computer application to retrieve four sets of skill units, based on four short case problems which are contained in

Appendix C. The results of this activity are shown in tables XI, XII, XIII, and XIV. For each participant, the list of selected skill units are shown. Each skill unit title is followed by an indication of the Zenger-Miller training program of which it is a part. The abbreviations indicate the following programs: FLL - FrontLine Leadership; Q - QUEST (Quality Enhancement Through Skills Training); TE - Team Effectiveness; TL - Team Leadership; W - Working; WSDWT - Working for Self-Directed Work Teams.

Table XI shows the retrieval results for the first case problem.

Participant 1	**Participant 2**
Quality: The Leadership Role (Q)	Fostering Improvement Through Innov. (FLL)
Focusing your team on Quality (Q)	Quality: The Leadership Role (Q)
Building Individual Commitment to Quality (Q)	Focusing your Team on Quality (Q)
	Expanding your Team's Capabilities (TL)
	Clarifying Team Roles & Responsibilities (FLL)
Participant 3	**Participant 4**
Quality: The Leadership Role (Q)	Quality: The Leadership Role (Q)
Building individual commitment to Quality (Q)	Focusing your Team on Quality (Q)
	Building Indiv. Commitment to Quality (Q)
	Sustaining Momentum for Cont. Improvement (Q)
Participant 5	**Participant 6**
Quality: the Individual's Role (Q)	Quality through the Eyes of the Consumer (Q)
Quality: the Leadership Role (Q)	Quality: the Leadership Role (Q)
Analyzing Work Processes (Q)	Analyzing Work Processes (Q)
	Solving Quality Problems (Q)
	Tools & Techn. for Solving Quality Problems (Q)
	Leading Quality Problem Solving Sessions (Q)

Table XI. Case Problem 1

The participants all viewed this case problem as a quality-related issue, but selected skill units based on their differing perspectives. However, virtually all selected skill units came from the Quest-series which focuses on quality. The most frequently selected units were: Quality - The Leadership Role (Q - 6 times), Focusing your Team on Quality (Q - 3 times), and Building Individual Commitment to Quality (Q - 3 times).

Table XII shows the retrieval results for the second case problem.

Participant 1	**Participant 2**
Facilitating for Results (FFR)	The Basic Principles of Teamwork (TE)
Introduction & Basic Principles (W)	Raising Difficult Issues with your Team (TE)
Listening to Understand Clearly (W)	Resolving Issues with Others (W)
Giving Feedback to Help Others (W)	Participating in Group Meetings (W)
Getting your Point Across (W)	Being a Team Player (W)
Resolving Issues with others (W)	
Participating in Group Meetings (W)	
Participant 3	**Participant 4**
Resolving Issues with Others (W)	The Basic Principles of Teamwork (TE)
Participating in Group Meetings (W)	Resolving Issues with Others (W)
Listening to other Team Members (WSDWT)	Participating in Group Meetings (W)
	Listening to Other Team Members (WSDWT)
Participant 5	**Participant 6**
The Basic Principles of Teamwork (TE)	The Basic Principles of Teamwork (TE)
Developing Team Plans (TE)	Keeping Your Team on Course (TE)
Listening to Other Team Members (WSDWT)	Raising Difficult Issues with your Team (TE)
Giving Feedback to Impr. Team Results (WSDWT)	Listening to Other Team Members (WSDWT)

Table XII. Case Problem 2

The participants viewed this case problem to be about the issues of team building and worker communication. So while the responses to this problem appear to show a great variety of units and programs, virtually all of the selected skill units address these two issues. The most frequently selected units were: The Basic Principles of Teamwork (TE - 4 times), Resolving Issues with Others (W - 4 times); Participating in Group Meetings (W - 4 times), and Listening to Other Team Members (WSDWT - 4 times).

Table XIII shows the retrieval results for the third case problem.

Participant 1	**Participant 2**
Your Role & the Basic Principles (FLL)	Analyzing Work Processes (Q)
Solving Problems: The Basic Process (FLL)	Solving Quality Problems (Q)
Solving Problems: Tools & Techniques (FLL)	Tools & Techn. for solving Qual. Problems (Q)
Facilitating for Results (FFR)	Participating in Qual. Problem Solving Sess. (Q)
Working Smarter (W)	
Participating in Problem-Solving Sessions (FLL)	

Table XIII. Case Problem 3

Participant 3	**Participant 4**
Solving Problems: The Basic Process (FLL)	Solving Problems: the Basic Process (FLL)
Solving Quality Problems (Q)	Leading Problem Solving Sessions (FLL)
Working Smarter (W)	Forward Thinking (TL)
Communicating Ideas to your Team (WSDWT)	Dealing with Changes (W)
	Participating in Problem Solving Sessions (FLL)
Participant 5	**Participant 6**
Solving Problems: The Basic Process (FLL)	Solving Problems: The Basic Process (FLL)
Solving Problems: Tools & Techniques (FLL)	Solving Problems: Tools & Techniques (FLL)
Participating in Problem Solving Sessions (FLL)	Participating in Qual. Probl. Solving Sess. (Q)
	Taking on a New Assignment (W)
	The Basic Principles (WSDWT)

Table XIII. Case Problem 3 (Continued)

The third case problem was generally perceived to be about the issues of problem solving and leadership. In fact, all participants selected either two or three skill units directly related to problem solving skills. Given that most of the selected units came from the FrontLine Leadership series, these units have a management and leadership orientation as well. The most frequently selected units were: Solving Problems: The Basic Process (FLL - 5 times), Solving Problems: Tools & Techniques (FLL - 3 times), and Participating in Problem-Solving Sessions (FLL - 3 times). Two participants who did not select the latter unit did select the highly complementary Participating in Quality Problem-Solving Sessions (Q - 2 times).

Table XIV shows the retrieval results for the fourth case problem.

Participant 1	**Participant 2**
Establishing Performance Expectations (FLL)	Dealing with Emotional Behavior (FLL)
Recognizing Positive Results (FLL)	Building a Foundation of Trust (TL)
Developing Job Skills (FLL)	Resolving Team Conflicts (FLL)
Coaching for Optimal Performance (FLL)	Raising Difficult Issues with your Team (TE)
Solving Problems: The Basic Process (FLL)	Resolving Issues with others (W)
Introduction & The Basic Principles (W)	Listening to other Team Members (WSDWT)
Keeping your Boss Informed (W)	
Participating in Problem-Solving Sessions (FLL)	

Table XIV. Case Problem 4

Participant 3	**Participant 4**
Building a Foundation of Trust (TL)	Your Role & The Basic Principles (FLL)
Launching & Refueling your Team (TL)	Giving Constructive Feedback (FLL)
Clarifying Team Roles & Responsibilities (FLL)	Getting Good Information from Others (FLL)
Resolving Team Conflicts (FLL)	Dealing with Emotional Behavior (FLL)
Facilitating for Results (FFR)	The Basic Principles of Teamwork (TE)
Making the Most of Team Differences (TL)	Keeping your Team on Course (TE)
The Basic Principles of Teamwork (TE)	Keeping your Boss Informed (W)
Keeping your Team on Course (TE)	Reinforcing Teamwork (WSDWT)
Listening to Other Members (WSDWT)	

Participant 5	**Participant 6**
Introduction & The Basic Principles (W)	Your Role & The Basic Principles (FLL)
Listening to Understand Clearly (W)	Giving Constructive Feedback (FLL)
Giving Feedback to Help Others (W)	Establishing Performance Expectations (FLL)
Keeping your Boss Informed (W)	Recognizing Positive Results (FLL)
Resolving Issues with Others (W)	Coaching for Optimal Performance (FLL)
Participating in Group Meetings (W)	Taking Corrective Action (FLL)
	Building a Constr. Relationship w/ your Mngr (FLL)
	Winning Support from Others (FLL)
	Introduction & The Basic Principles (W)
	Taking on a New Assignment (W)
	Keeping your Boss Informed (W)

Table XIV. Case Problem 4 (Continued)

One of the participants mentioned that case problem 4 was rather vague. The skill unit retrieval results seem to echo that sentiment, as the participants perceived this problem from different angles. Indeed, while most of the selected units came from the FrontLine Leadership program, there appears to be little agreement on which units from this program would be appropriate to address this case problem. However, despite the apparent differences there is a common thread in the six selections: each participant appears to address the issue of interpersonal communication, with the issues of coaching and teamwork being strong secondary topics. Given that many, if not most, of the available skill units address some aspect of interpersonal communication, the variety of selected units should not be a complete surprise. The most frequently selected units were: Keeping your Boss Informed (W - 4 times) and Introduction and the Basic Principles (W - 3 times).

5.4.3 Satisfaction Analysis Results

After completing the knowledge retrieval activity, the participants were asked to fill out a questionnaire about their experience with the computer application, the Knowledge Cube, and the task they had just performed. The questions were to be answered on a seven-point Likert-type scale. In addition, they were asked to write down additional comments on how to improve the application and the knowledge structure.

The seven-point Likert-type scale is shown in figure 32. The scoring used in this section was performed as follows: the value of one through seven were assigned to the responses, with one being assigned to "completely agree" and seven being assigned to "completely disagree." The scores were then averaged for the six participants. The lower the average score, the more positive the participants felt about the statement responded to.

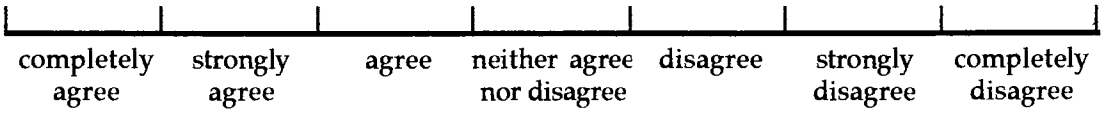


Figure 32. Questionnaire Likert-type Scale.

Table XV lists the questions on the satisfaction analysis questionnaire. For each question the distribution of the individual responses is shown (E designates a content expert, N designates a non-content expert), as well as the average score.

KNOWLEDGE RETRIEVAL SATISFACTION ANALYSIS ITEM	completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree	mean
The FoxPro Application								
1. The computer-application was easy to use.		N	E E E N N					2.83
2. The help-screens provided by the application were useful and informative.		N	N	E E E N				3.50
3. It was clear what types of input the application required.		E E N	N N		E			2.83
4. The reports generated by the application were useful.		E N N N	E E					2.33
5. The application's screen-layouts were clear.			E E N N N		E			3.33
The Knowledge Structure								
1. The Knowledge Structure appears to be a useful method for organizing skill units.		E N N	E N		E			2.83
2. The Knowledge Structure appears to be a clear method for organizing skill units.		N N N	E E	E				2.67
3. The Knowledge Structure appears to be a sensible method for organizing skill units.		N N N	E E E					2.50

Table XV. Knowledge Retrieval Satisfaction Analysis Results.

KNOWLEDGE RETRIEVAL SATISFACTION ANALYSIS ITEM	completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree	mean
4. The Knowledge Structure appears to be a complete method for organizing skill units..		N N	N	E E	E			3.33
5. The 3-level content-dimensions is useful when organizing skill units.		E N N N	E E					2.33
6. Having a purpose-aspect is useful when organizing skill units.		E N N	E E N					2.50
7. The 6-level audience dimension is useful when organizing skill units.		E N N	E E N					2.50
The Task								
1. The training criteria provided were quite clear.		E N N N	E E					2.33
2. It was easy to find one or more skill units which fit the provided training criteria.	N	E N N	E E					2.17
3. I felt quite comfortable selecting the skill units.		E N N N	E		E			2.67
4. I thought the process of retrieving the skill units was effective.		N N	E N		E E			3.33
5. I would use this application again for the task of retrieving skill units.		N N	E E N		E			3.00

Table XV. Knowledge Retrieval Satisfaction Analysis Results. (Continued)

It must be noted that on the Likert-type scale questions for all three sections, the non-content experts tended to respond more positively than the content experts.

The following are the responses to the two open-ended questions on the satisfaction analysis questionnaire.

The FoxPro Application – How might this application be improved?

- You took our comments.
- Double-click instead of close-box.
- Simplify search criteria (fewer).
- It would be helpful to avoid the step of having to do a new search every time you want to go back to the list (i.e. you know you're going to select more units from the list).
- The ability to undertake multiple keyword searches and then combine them would be useful.
- Windows to cut down recycle back through to produce multiple list.

The Knowledge Structure – How might this knowledge structure be improved?

- We told you.
- With so few "knowledge components" - i.e. unit titles, multiple criteria (5) often yield nothing.
- My only concern is that somewhere, someone has to define the words that describe the objective/purpose/audience for the unit - as long as that is done accurately and consistently I feel quite comfortable with the results.
- If ZM had multiple delivery methods, then that dimension would be useful.
- The database usefulness will depend on interpretation for inclusion of skill units. Participant needs a level of background information.

5.4.4 Additional Participant Comments and Researcher Observations

Time: All participants required substantially less time for the last few case problems than they did for the first and second. Again, the application's interface - in particular learning how to define a search - appears to account for this. The average time needed to perform the task was 37.67 minutes (standard deviation = 12.24). Differences between the content experts and the non-content experts in time needed to complete the task were not completely obvious. However, the shortest time needed to complete the task (21 minutes) was recorded for a content expert, and the longest time needed (58 minutes) was recorded for a non-content expert. The other four participants were more difficult to distinguish (32, 35, 38, and 42 minutes).

Application: The content experts described the search and selection process of the application as laborious and tedious, especially when they wanted to select several skill units from a search result but were able to select only one unit at a time. Non-content experts were not as annoyed by this because they generally looked at only a single unit at a time.

Application: Suggested application interface improvements include: the ability to select multiple skill units from a search result and the ability to put these selected units on the selection list as a group, rather than one by one; the ability to erase units from the selection list after they have been placed on it; the ability to have the current selection list constantly in view in a window while searching for additional skill units; the ability to limit a keyword search by combining it with aspects of the knowledge structure search (such as audience).

Knowledge Cube: Most participants tried to use the knowledge structure search type rather than the keyword searches. However, the more closely they defined their

search (by defining aspects on all three Knowledge Cube dimensions), the more likely they found few or no skill units to match their search criteria. Consequently, the participants defined broader searches as they progressed with the task.

Knowledge Cube: When using the keyword search options, the participants would often run into the two problems common to keyword searches (see section 2.5.1). That is, they would not find all the skill units they had hoped to find because they did not have the particular keyword in their description, or they found too many skill units because the keyword was too common. Consequently, one of the arguments in favor of an explicit knowledge structure, such as the Knowledge Cube, was inadvertently confirmed by the current study.

Task: A substantial limitation of the task - mentioned by all participants - was that the skill units in the database had been classified by the researcher, rather than by a content expert. Consequently, some skill units were not where the participants would have looked for them. When this occurred, some participants preferred to use a keyword-search to search for the title of the desired skill unit.

Task: The content experts rarely looked at the description of a skill unit once it had been selected: the title, when combined with their personal knowledge about the skill unit, provided sufficient information to make a decision as to whether or not to place the unit on the selection list. Non-content experts would frequently inspect the skill unit description before making their decisions.

Task: One content expert mentioned that the use of the application was slow compared to the manual method: she knew the skill units so well that she would rather write down a list of suggested skill units rather than use the application to search for them. She acknowledged, however, that at this time the number of skill

units available from Zenger-Miller is not too large to keep track of; when the number of skill units would increase drastically, she could perceive a need for an automated tool to help select the skill units.

5.4.5 Analysis of Knowledge Retrieval Activity Results

The analysis of the knowledge retrieval activity results is dominated by the same three issues which were found during the knowledge organization activity: the effectiveness of the Knowledge Cube, the differing expertise levels of the study's participants, and the possibility of the multiple classification of knowledge. The following subsections, then, show how the knowledge retrieval activity results relate to these three issues.

Knowledge Cube Effectiveness

As during the knowledge organization activity, the participants' verbal comments mainly addressed the automated application, rather than the Knowledge Cube itself. On the knowledge retrieval satisfaction analysis, however, the participants responded quite positively to the Knowledge Structure-specific items. In fact, on all but one question, the responses were more positive after the knowledge retrieval activity than after the knowledge organization activity. The participants appear to favor the Knowledge Cube for knowledge retrieval purposes.

An additional indicator of the acceptance of the Knowledge Cube architecture for knowledge retrieval purposes lies in the fact that most participants were able to select the skill units needed to address a case problem with a small number of searches. Such a search would often be followed by the selection of several skill units from the results of that particular search. This would imply that the study's participants felt that utilization of the Knowledge Cube provided them with an appropriate subset of the entire skill unit

collection.

Again, it would appear that the flexibility of the Knowledge Cube contributes substantially to these positive impressions. The results of the knowledge retrieval activity appear to show relatively low levels of agreement on which specific skill units to select to address the provided case problems. However, the general content area for which skill units were selected for each case problem shows greater levels of agreement. It would seem, then, that within the boundaries of the case problems the Knowledge Cube allowed the participants to apply their own perspectives, insights, and knowledge to their usage of this knowledge structure. In other words, the participants were able to retrieve knowledge units to support their individual approaches in order to solve the case problems

Participant Expertise Levels

The difference between participants highly familiar with all of the skill units (the content experts) and those not very familiar with all skill units (the non-content experts) was as apparent during the knowledge retrieval activity as it had been during the knowledge organization activity. Again, the differences between these two groups appear both in how they used the Knowledge Cube and in how they evaluated its usefulness.

During the knowledge retrieval activity, the content experts would, upon reading the case problem, quickly decide for themselves which skill units were needed. Then would then use the application to find the titles they wanted, frequently by using a keyword search. The non-content-experts, on the other hand, generally relied on a Knowledge Cube dimensions search in order for the application to suggest skill units to them. They would read the individual skill unit description, and only then decide whether or not to select the skill unit for inclusion in the training program.

Differences in perception between content experts and non-content experts were quite evident in the results of the satisfaction analysis administered after the knowledge retrieval activity. Using once again a manual examination of the participants' responses, the results show that the non-content experts responded more positively than the content experts on all seven questions relating to the Knowledge Cube and its dimensions. The non-content experts, then, perceived the knowledge structure to be a more effective method for organizing skill units than the content experts.

In addition, the non-content experts perceived to receive a positive benefit from their usage of the Knowledge Cube, particularly for the process of knowledge retrieval. Their responses to the five questions regarding the use of the Knowledge Cube for the knowledge retrieval task were substantially more positive than the responses of the content experts.

The non-content experts did not only perceive to receive support from the Knowledge Cube for knowledge retrieval purposes: the results of the knowledge retrieval activity indicate that the non-content experts were indeed aided in their task by the Knowledge Cube. Given that the non-content experts and the content experts located and retrieved fairly similar sets of skill units for the four case problems, it would appear that to some extent the differences in expertise-levels can be overcome by using the Knowledge Cube for knowledge retrieval. In other words, using the Knowledge Cube, a non-content expert was able to perform knowledge retrieval at a level approximating that of a content expert.

The results for the non-content experts become more important when one considers a comment made by one of the content experts who took part in the study. The content expert suggested that the Knowledge Cube would likely be more useful when the number of Zenger-Miller skill units increased to the point where it would be difficult to remember

them all. In more general terms, this would mean that the larger a knowledge base becomes, the less likely it is for a content expert to be familiar with all the knowledge contained in the knowledge base. At some point even content experts would need some degree of support to retrieve the required knowledge from the knowledge base. When the amount of knowledge exceeds the content experts' cognitive capacity to retain it all, a knowledge organization structure such as the Knowledge Cube is likely to be perceived more positively by content and non-content experts alike.

Multiple Classification of Knowledge

During the knowledge retrieval activity, it became apparent that the multiple classification of knowledge would be helpful to accommodate the various perspectives and expertise-levels of Knowledge Cube users. Frequently the results of a multi-dimensional knowledge structure search would come up empty, even though the participant fully expected one or more skill units to exist for the combination of provided search criteria. However, the fact that no skill units were found for the given search criteria would not not necessarily mean that no skill units addressed those criteria. Rather, the skill units had been classified otherwise. Multiple classification would leave fewer such fillable gaps in the knowledge structure, increasing the hit-rate of a multidimensional search and allowing people with different backgrounds to find the same skill unit given different searches.

5.5 The Potential Need for Multiple Knowledge Classification

Multiple classification of knowledge in a knowledge organization framework relates to the possibility of classifying knowledge into more than a single category. For the Knowledge Cube, this means that a single piece of knowledge can address more than one content-area, subject, or topic, that it can have more than one purpose, or that it can address more than one type of audience.

None of the knowledge organization structures reviewed in section 2.5.4 allow for the multiple classification of knowledge. However, the need for and the potential benefits of multiple classification became quite apparent in the course of the study. Multiple classification of knowledge has the potential to improve the effectiveness of both knowledge organization and knowledge retrieval.

During knowledge organization, multiple classification requires fewer difficult decisions on how to uniquely classify pieces of knowledge, nor does it require any questionable solutions to such problems. For example, the knowledge classification rules of the Dewey Decimal Classification system - which does not allow multiple classification - include the following possible tradeoff for the purpose of singular classification of knowledge: "If two subjects receive equal treatment ... class the work with the subject whose number comes first in the DDC Schedules." (Comaromi, et al., 1989, p. xxxi) Multiple classification, on the other hand, allows one to classify a piece of knowledge into all the categories which seem appropriate and therefore reduces the need for making tradeoffs between two or more equally appropriate classifications.

Multiple classification might not only make knowledge organization easier to perform, but it can also enhance the knowledge retrieval activity. Given that the participants were found to organize the skill units in different ways, it appears reasonable to expect that they would also search for these skill units in different places. Consequently, multiple classification allows a variety of Knowledge Cube users to be able to locate and retrieve the knowledge they need, given their different backgrounds and perspectives. Using multiple classification, users with different backgrounds or levels of expertise can classify single piece of knowledge in several ways. In addition, they will be able to locate the same piece of knowledge using a variety of searches, thereby making the search-process more effective.

The drawbacks of the multiple classification of knowledge might include knowledge base redundancy, reduced data storage efficiency, reduced knowledge search precision, and reduced knowledge base classification quality. Moreover, multiple classification is not part of the original definition of the Knowledge Cube, and it contradicts the final organizing principle which addresses the need for consistent application of a knowledge structure. (See section 3.7.3) Nevertheless, the results of this study warrant the investigation of the benefits and drawbacks of multiple classification as an extension to the Knowledge Cube. (See section 6.5)

5.6 Review of Knowledge Cube Organizing Principles

Finally, the five organizing principles behind the Knowledge Cube (section 3.7.3) need to be reviewed to determine whether they were met by this particular implementation of the knowledge organization structure.

1. **The knowledge structure should combine purpose and content.**

   The Knowledge Cube implementation included both content and purpose as organizing dimensions. Both the content dimension and the purpose dimension were deemed valuable by the study's participants.

2. **The knowledge structure should apply to organization and retrieval.**

   The application which implemented the Knowledge Cube allowed the knowledge structure to be applied to both the organization and retrieval of knowledge. Results indicated that the study's participants preferred the Knowledge Cube for usage in knowledge retrieval over knowledge organization.

3. **The knowledge structure should be generally applicable.**

   The Knowledge Cube was implemented for only a single knowledge base, and consequently the generalizability of its application can't yet be evaluated. However, no indications were found that the Knowledge Cube was particularly suited for any particular type of knowledge or knowledge base.

4. **The knowledge structure should be dynamic.**

   The Knowledge Cube implementation was dynamic in that the study's participants were able to add new knowledge to the knowledge base and new categories to the Knowledge Cube structure.

5. **The knowledge structure should be designed for consistent application.**

   The results of this study indicate that this organizing principle as stated in section 3.7.3 was not met. The participants' level of expertise with the knowledge as well as their professional backgrounds and personal preferences resulted in a variety of knowledge organization and retrieval results. However, on a higher level, the results of both the knowledge organization and knowledge retrieval activities showed reasonable levels of agreement among the participants. Thus it can be asserted that use of the Knowledge Cube leads to a moderate level of consistency, but not to complete consistency.

CHAPTER VI

SUMMARY & CONCLUSIONS

6.1 Introduction

This chapter describes the conclusions which were drawn from the case study results described chapter 5. In addition, limitations of the current study, as well as suggestions for further research are included. This chapter, then, brings the current research project to a close and in addition provides a starting point for further research. The following sections make up this chapter:

- Section 6.2 summarizes the study.
- Section 6.3 contains the case study conclusions, and relates these back to the original proposition on the topic of knowledge organization and the case study questions and propositions.
- Section 6.4 contains the limitations of the case study.
- Section 6.5 contains suggested further research on the topic of knowledge organization and on the knowledge theory as a whole.

6.2 Research Summary

This dissertation research project was based on a set of five objectives (section 1.2). The following list summarizes how these five objectives were realized:

1. A general theory of knowledge, knowledge manipulation, and knowledge organization was proposed in chapter 3. This theory is based on the literature review of the subjects of knowledge, knowledge utilization and management, and

knowledge organization, which is contained in chapter 2.

2. A general knowledge organization framework based on the proposed theory, called the Knowledge Cube, is described in section 3.7.

3. A particular instance of the Knowledge Cube was developed for the organization of training materials at Zenger-Miller, Inc. This instance is described in section 4.5.6.

4. A prototype application was developed to implement the Knowledge Cube instance for Zenger-Miller. This application is based on the functional design contained in section 4.3. The application itself is described in detail in Appendix A.

5. The prototype application which implements the Knowledge Cube was tested at Zenger-Miller, Inc. using the case study method as defined by Yin (1984). The research methodology is outlined in section 4.4. while the research instruments are contained in Appendices B and C. Finally, the results and analysis of this case study are contained in chapter 5.

The current chapter completes this dissertation by drawing conclusions from the case study and relating these conclusions back to the proposed theory of knowledge organization. In addition, this chapter describes the limitations of this research project and some possibilities for future research.

6.3 Knowledge Cube and Case Study Conclusions

6.3.1 Introduction

This conclusions section is comprised of four main parts. The first two subsections each describe a conclusion based on the case study results and analysis described in chapter 5. These conclusions relate to the effectiveness of the Knowledge Cube and a distinction between Knowledge Cube user types. The following two subsections summarize these conclusions and relate them back to the case study questions and the original proposition posed by the Knowledge Cube theory. Following the research design outlined in section 4.4.7.4, these conclusions are based on both the Knowledge Cube's objective aspects (the results of the knowledge organization and retrieval activities) and its subjective aspects (the participants' experiences and perceptions, as reflected in verbal comments and the satisfaction analysis).

6.3.2 Knowledge Cube Effectiveness

Conclusion 1 - The Knowledge Cube is perceived to be an effective knowledge organization structure.

The Knowledge Cube, as implemented by the automated application, was generally positively received by the participants in the study. The results of the satisfaction analysis instruments, as well as the verbal comments of the participants indicate that the Knowledge Cube is a step forward in the area of knowledge organization.

More specifically, the study's results indicate that users of the Knowledge Cube preferred it for knowledge retrieval rather than for knowledge organization. The results of the satisfaction analysis indicate that the Knowledge Cube was perceived to be more useful,

clearer, more sensible, and more complete during the retrieval activity than during the organization activity. However, to what extent the user's perceptions of the software application influenced their assessment of the Knowledge Cube can not be determined with certainty.

The positive perception of the Knowledge Cube for retrieval purposes is a welcome finding, as any knowledge organization structure would likely be used far more often for knowledge retrieval than for knowledge organization. The prerequisite for effective retrieval is of course that the knowledge has been properly organized by people familiar with the knowledge and the ways in which it may be perceived and used by those who are to retrieve it.

In short, it can be concluded from this initial study that Knowledge Cube is a useful and effective structure for the organization and retrieval of knowledge.

6.3.3 Knowledge Cube User Types

Conclusion 2 - The level of familiarity with the knowledge affects the usage and perception of the Knowledge Cube.

In the course of the study, it quickly became apparent that the participants' differing levels of familiarity with the skill units made a significant difference in how the Knowledge Cube was used and perceived. Three of the participants (referred to as content experts) knew all of Zenger-Miller's skill units quite well. The other three participants (non-content experts) were not highly familiar with all of the skill units.

Differences in usage of the Knowledge Cube between the non-content experts and the content experts were visible both during the knowledge organization activity and the

knowledge retrieval activity. The non-content experts needed and used the knowledge organization support provided by the Knowledge Cube. The content experts did not appear to need the Knowledge Cube's support for knowledge use.

Differences in perception of the Knowledge Cube between the non-content experts and the content experts was also quite visible during both activities. The non-content experts perceived the Knowledge Cube to be substantially more useful than the content experts did.

It appears, then, that a person's level of familiarity with the knowledge contained in the Knowledge Cube directly affects the real and perceived usefulness of the Knowledge Cube to that person, particularly for the task of knowledge retrieval, and hence that person's approach to using the Knowledge Cube. This may be due to the notion that a knowledge organization structure would be most useful when it allows its user to discover something new. When all the knowledge that is contained in the knowledge organization structure is already known, usage of the structure provides little or no cognitive benefit to the user. Moreover, the more familiar a person is with the knowledge content, the more likely it is that an internal organization of the knowledge exists. Consequently, an alternative knowledge organization structure, such as the Knowledge Cube, would be of limited use to such a person. However, an indication was found that when a knowledge base is sufficiently large to exceed a content expert's cognitive capacity, it is possible for content experts to see the Knowledge Cube in a more positive light.

6.3.4 Response to Case Study Questions

This section summarizes the results of the study by providing responses to the case study questions and proposition posed in section 4.4.5.

Case Study Question #1: How can the Knowledge Cube/application prototype help Zenger-Miller organize its skill units? (See section 4.4.5)

The combination of the Knowledge Cube and the automated application organizes the skill units by providing a framework of three relevant dimensions (content, purpose, and audience) by which the units can be accessed. As such, the knowledge structure can provide assistance when selecting skill units for inclusion into a training program such as Zenger-Miller's Designed Systems. While the primary application of this tool appears to be in the area of sales and consulting, it was found that Zenger-Miller's sales and consulting associates - given their high levels of expertise on skill unit content - are the least likely to need this tool given the current situation. Only when the number of skill units becomes so large as to become unmanageable may the sales and consulting associates have a need for the knowledge structure and the application.

However, this does not necessarily mean that the Knowledge Cube and the automated application can't be useful to Zenger-Miller. The expert classification of the skill units can provide the company with an opportunity for organizational learning (Dixon, 1992). The individual expertise of the content experts about the various ways in which the skill units can be perceived and applied could be gathered and distributed throughout the organization to support both development and sales efforts.

In addition, the expert classification of the skill units can provide the company's marketing and development functions with information on product refinement and new product development. Empty areas in the Knowledge Cube - gaps not currently filled by skill units - provide opportunities for expansion. Existing skill units can be broadened, refocused, or enhanced to cover a larger area of the knowledge structure. Completely new skill units can be developed as well. Given that the existing skill units already overlap somewhat - covering similar problems from different perspectives such as the managerial

or the non-supervisory employee perspective - using the Knowledge Cube for this purpose does not completely contradict existing development efforts.

Finally, the combination of the Knowledge Cube and the automated application can also be used as a marketing tool. It can help outside organizations which are reasonably familiar with Zenger-Miller products and which frequently use them to make training-decisions for which Zenger-Miller consultants are not always needed. For example, the Human Resources departments of some of the larger Zenger-Miller clients can use the application - particularly its skill unit search and selection module - to select appropriate skill units for worker training. Members of Zenger-Miller's Education and Economic Development (EED) network, such as vo-tech institutions, could use the application for similar purposes.

> **Case Study Question #2:** Is the Knowledge Cube perceived to be either more or less useful than other methods for organizing skill units employed by this company? (See section 4.4.5)

At this time, Zenger-Miller has no functional organization method for its skill units other than the way they are combined into courses. However, as the individual consideration of skill units for the purpose of training increases, the course title alone may no longer be sufficient. Zenger-Miller recognized this need and in 1993 organized a subset of its skill units in a two-dimensional structure which it called "The TotalTeam Solution Assessment Matrix." However, a general skill unit organization method has not yet been developed. Consequently the combination of the Knowledge Cube and the automated application appears to fill a recognized need for more effective skill unit selection.

It was found, however, that the use of the Knowledge Cube was perceived to be more useful by those not familiar with the skill units than by those who are highly familiar

with the skill units and who already have some form of mental organization of the units - particularly for the purpose of knowledge retrieval.

It was also found that an important requirement for success is the careful organization of the knowledge by a people highly familiar with the knowledge. Given the results of the knowledge organization activity, it is likely that having multiple content-experts organize the knowledge can lead to multiple classification of some skill units. This, it turn, allows people with different backgrounds and points of view to search for knowledge more effectively. (See section 5.5)

Given these two requirements - knowledge organization by content experts and multiple classification - it is likely that the Knowledge Cube would be perceived to be quite useful by those with a need for knowledge retrieval support.

> **Case Study Proposition**: The Knowledge Cube, when applied to the organization of skill units, facilitates easy and effective retrieval of Zenger-Miller's training materials by its employees. (See section 4.4.5)

The results of the case study indicate that the case study proposition is true, given a significant qualification: only those participants in the study with limited knowledge of the skill units, the non-content experts, felt that they received positive benefits of the Knowledge Cube. It was found that participants highly familiar with the skill units preferred their personal, internal method of organization over that of the Knowledge Cube.

Based on the positive comments and results on the knowledge retrieval satisfaction analysis, it appears that the non-content experts perceived the Knowledge Cube to provide **easy** retrieval of the skill units. In addition, the Knowledge Cube also appears to facilitate the **effective** retrieval of skill units, particularly by the non-content experts. A good

indicator for the latter is provided by the results of the knowledge retrieval activity: the non-content experts and the content experts located fairly similar sets of skill units for each of the four case problems. Thus it can reasonably be assumed that to some degree, the differences in expertise-levels were overcome by using the Knowledge Cube for skill unit retrieval.

6.3.5 Response to Knowledge Theory Proposition

This section summarizes the results of the study by providing a response to the knowledge organization theory proposition posed in section 3.3.3.

> **Knowledge Organization Theory Proposition**: The practice of knowledge organization facilitates successful knowledge utilization.

This proposition, the fourth of the series of knowledge theory propositions put forth in section 3.3.3, simply states that knowledge can be utilized more effectively after it has been organized according to some framework or structure. In the context of the original knowledge theory described in chapter 3, knowledge organization in the proposition refers to the Knowledge Cube, a three-dimensional structure for knowledge organization described in section 3.7.6. Knowledge utilization refers to the processes of knowledge creation, discovery, deployment, destruction, consultation, and exploration as described in section 3.5.2.

The current study addressed the processes of knowledge discovery (the structuring of knowledge, the subsequent filtering of knowledge from the knowledge base, and the composing of pieces of knowledge to address a case problem), knowledge consultation (the reading of skill unit descriptions - a summary of the actual knowledge - following a search), and - to a limited extent - knowledge deployment (initiating the use of knowledge

to address a case problem). Conclusions about the effects of knowledge organization on knowledge utilization are therefore directed at these three processes.

Knowledge discovery. The Knowledge Cube and its automated application provided the study's participants with the means to structure new knowledge into a knowledge base, filter or select knowledge from the knowledge base using various search-types, and compose pieces of knowledge into a larger set using the selection list feature. The overall positive perception of the Knowledge Cube would indicate that knowledge discovery was successfully supported. However, some qualification of the benefits of the Knowledge Cube for these three activities is in order. First, while the study's participants were generally positive about the Knowledge Cube's three dimensions as a way of structuring knowledge, the actual structuring activity was generally perceived to be difficult. Second, the Knowledge Cube's support for filtering or selecting knowledge from the knowledge base was perceived to be positive only by the non-content experts, that is, those participants not highly familiar with the contents of the knowledge base. It appears that when all the knowledge is known to a person, an internal organization method takes precedence over an outside method such as the Knowledge Cube. Third, the composition or combination of knowledge was not extensively implemented in the automated application, nor was this function an essential part of the Knowledge Cube. Overall, though, the Knowledge Cube can be said to support knowledge discovery.

Knowledge consultation. Knowledge consultation - the examining of knowledge after some type of search process - was limited in the current study in that the participants did not view the actual knowledge (the skill units) but a summary of what these skill units contain. This activity is not directly supported by a knowledge organization method such as the Knowledge Cube. Rather, the level of

support for this activity depends on how the Knowledge Cube was implemented, such as in this case by the automated application. Knowledge organization, therefore, cannot be said to support knowledge consultation.

Knowledge deployment. The current study did not specifically examine whether the deployment of the retrieved knowledge actually improved the eventual outcome of a decision-making, problem-solving, or other type of knowledge deployment process. However, for any knowledge deployment process it is important that the appropriate knowledge is readily available. Therefore, if the Knowledge Cube can be said to be able to provide this needed knowledge, it can be argued that at the least this method of knowledge organization enhances its deployment. Given that the Knowledge Cube was indeed perceived to provide effective knowledge retrieval (see section 6.3.2), knowledge organization appears to support knowledge deployment.

In summary, then, it appears that knowledge organization provides support for a subset of the knowledge utilization processes. Thus the original proposition, that knowledge organization facilitates successful knowledge utilization, is not contradicted by the results of the study.

6.4 Limitations of the Research

The nature of the current research is exploratory in that it is an initial investigation of the Knowledge Cube for the purposes of knowledge organization and retrieval. The use of the case study method was particularly helpful in this regard, in that it allowed the researcher to uncover aspects of the Knowledge Cube and its usage which may not have been found otherwise. However, the case study is subject to the following limitations.

- **Limited Generalizability.** The most obvious limitation of the case study is that of limited generalizability. The current study was performed in only a single organization, using both participants and knowledge materials from that organization. Consequently, the findings from this study need not necessarily apply to other organizations and other types of knowledge materials. However, the study does provide guidance for performing similar research in other organizations. Future research on the use of the Knowledge Cube in other organizations would reduce the generalizability problem.

- **Use of Qualitative Measures.** The case study and its conclusions are almost entirely based on the assessment of qualitative measures. The lack of quantitative measures, such as statistical indicators, places limits on the extent to which the available evidence is able to support the conclusions. Given the study's objectives and subject matter, though, the qualitative measures used in this study were felt to provide a sound means for capturing and comprehending its concepts.

- **Lack of Comparative Measures.** The current case study was performed without a control group which used an alternative method for knowledge organization and retrieval or no method at all. Consequently comparative statements such as "the Knowledge Cube is more effective than any other knowledge organization method" can not be made. Evaluation of the Knowledge Cube's effectiveness was therefore limited to the participants' perceptions of its effectiveness and the observation of the results of the knowledge organization and retrieval tasks. Future research in organizations which currently employ a knowledge organization method would deal with the current lack of comparative measures.

- **Lack of Longitudinal Measures.** The case study's participants performed both the knowledge organization and knowledge retrieval tasks only once. Thus the

study does not address the consequences of familiarity and experience with the Knowledge Cube. Performing a longitudinal study of this kind in a business organization, however, may not be practical in that the singular study already required substantial organizational resources. In addition, the exploratory nature of this study, along with the improvements suggested by the participants, would suggest that the Knowledge Cube should be evaluated and possibly improved before undertaking a follow-up study. A possible future research design consisting of a series of data collection processes would deal with the current lack of longitudinal measures.

- **Lack of direct access to Knowledge.** A limitation of the implementation of the Knowledge Cube in this study is that the study's participants had access only to meta-knowledge (such as title and descriptions), not to the actual knowledge (the skill units) itself. Consequently, the effects of the use of the Knowledge Cube and its accompanying application on the complete set of knowledge utilization processes could not be explored.

The experience and findings of the current study can be used to both deal with the limitations of the current study and discover more about the effectiveness of the Knowledge Cube for the purpose of organizing knowledge. The following section outlines possible future research efforts.

6.5 Future Research

The findings of the current study provide a clear direction for future research within the area of knowledge organization. The most immediately obvious need for future research concerns the Knowledge Cube itself, along with its companion application. Additional research would branch out to the other aspects of knowledge utilization and

management.

The current findings suggest a series of improvements to be made for future study. The participants' suggestions for improving the automated application contain many ideas worth implementing. Many of these suggestions affect the application's interface, not the method for knowledge organization itself. However, if the application is to be an effective implementation of the Knowledge Cube, the application's interface should be clear and easy to use.

The study's results also suggested a substantial enhancement of the Knowledge Cube architecture itself: the potential benefits of allowing for the multiple classification of knowledge. (See section 5.5) A change can be made in both the Knowledge Cube and its automated application to implement this. Subsequent testing can determine whether the surmised benefits of multiple classification - easier knowledge organization and more effective knowledge retrieval - can actually be realized and whether the possible drawbacks of multiple classification - reduced data storage efficiency, reduced knowledge search precision, and reduced knowledge base classification quality - actually occur.

Future research on the Knowledge Cube should also more systematically investigate the effects of content expertise among the Knowledge Cube's users. The findings in the current study regarding the perceived usefulness of the Knowledge Cube given various levels of content expertise are interesting but require additional corroboration.

Future research on the Knowledge Cube should also be able to eliminate several of the previously mentioned limitations of the study. By performing research in different organizations using different knowledge bases, the generalizability of the Knowledge Cube theory and the research results can be substantially improved. Following such additional exploratory studies, longitudinal research can be performed to examine the effectiveness

and perceived usefulness of the Knowledge Cube as users become increasingly familiar with this knowledge organization structure. Research in organizations which already employ some form of knowledge organization would allow for comparative results regarding the effectiveness of the Knowledge Cube. Finally, the development of a Knowledge Cube application with on-line access to the actual knowledge represented in the Knowledge Cube can lead to more substantial findings on the effects of Knowledge Cube usage on the knowledge utilization processes and on the possibility for organizational learning.

Once more research has been performed in the area of knowledge organization, research efforts can be broadened to include the other components of the knowledge theory proposed in chapter 3. Knowledge organization relates closely to knowledge utilization, which would therefore be a good starting point for further exploration of the knowledge theory. Subsequently, the other components of the theory - such as short-term and long-term knowledge management and the combined results of the set of knowledge activities on organizational performance - can be made part of the empirical research.

Initially, most aspects of the proposed future research will be of an exploratory nature. It is suggested that this research continues the use of the case study method in organizational settings. In the current study, the case study method has allowed for the discovery of substantial and interesting results which might not have been found using other research methods.

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Zenger-Miller Brochures and leaflets.

APPENDIX A – APPLICATION DESCRIPTION

A.1 Introduction

This appendix describes the application developed to test the Knowledge Cube at Zenger-Miller, Inc. The application was implemented on the Apple Macintosh platform using Microsoft FoxPro, version 2.5, on the Macintosh. FoxPro is a relational database management package which allows for the development of database applications using screen-, report-, and menu-generator utilities. Consequently, all database files, screens, reports, and programs mentioned in this appendix were created using the FoxPro package.

A.2 File Structure

The application uses four relational tables. The key which connects these tables and uniquely identifies each database entry is the node identification number. The following are the files used by the application.

KNSTRUC – This file contains the knowledge-structure attributes of the skill units. The following fields exist in this file:

Field	Format	Description
Id	Character, 8 places, key.	Unique identification number
Area	Character, 45 places.	Area for content dimension
Subject	Character, 45 places.	Subject for content dimension
Topic	Character, 45 places.	Topic for content dimension
Purpose	Character, 45 places.	Purpose description
Audience	Character, 35 places.	Target audience

IDSEG – This file contains the identification-segment attributes of the skill units. The following fields exist in this file:

Field	Format	Description
Id	Character, 8 places, key.	Unique identification number
Title	Character, 65 places.	Title of skill unit
Program	Character, 50 places	Title of program the unit belongs to
ZMid	Character, 15 places	Zenger-Miller course number
Ponsi	Character, 65 places	PONSI course number and title
Instruct	Character, 34 places	Instructor type required
SupMat	Character, 50 places	Support materials available
StudYr	Numeric, 7 places	Number of students per year
AvCls	Character, 7 places	Average class size
TimeCmpl	Character, 12 places	Time needed to complete unit
ReqCmpl	Character, 65 places	Completion requirements
PreAct	Character, 65 places	Prerequisite activities or instruction
PreWork	Character, 65 places	Prerequisite work experience
PreEduc	Character, 65 places	Prerequisite formal education
OutWork	Character, 65 places	Outside work required
StText	Memo-field	Standard texts available for this unit
Descrip	Memo-field.	Brief description of skill unit

IDNR – This file contains a sequence number in a single record. Each time a new unit is added to the database, the current number is taken from the record. The prefix ZM is added to make it a non-numeric key, the whole of which is then used as a unique unit identification. The value in this file's single record is subsequently increased by one.

Field	Format	Description
Number	Numeric, 6 places, key.	Sequence number for unit ID-fields

XLIST – This is a temporary file which keeps track of the selection-list when the user searches for units to select. In this list, units are identified by their identification numbers only.

Field	Format	Description
Xid	Numeric, 8 places, key.	Unique identification number

A.3 Application Logical Structure

A.3.1 Introduction

The following sections describe the main functions of the prototype application. Each of these functions is implemented using one or two screens. The functions are:

- Section A.3.2: Main Menu.
- Section A.3.3: New Unit Entry.
- Section A.3.4: Reports.
- Section A.3.5: Knowledge Structure Description.
- Section A.3.6: Database Searching.
- Section A.3.7: Unit Selection.
- Section A.38: Unit Viewing.
- Section A.3.9: Unit Editing.
- Section A.3.10: Unit Deletion.
- Section A.3.11: Quit Application - Section.

A.3.2 The Main Menu

Using the main menu, a user is able to select any of the main application functions or exit the application. The main menu is shown in Figure 33.

The main menu's five options, as well as the additional functions of the application, are described in the following sections.

A.3.3 New Unit Entry

Entering a new database item requires that the user classify and describe the skill units. The first data entry screen, shown in Figure 34, classifies the skill units in the three dimensions of the Knowledge Cube. Through the use of pop-up menus, the user is able to select from existing classifications or add a new classification to the database.

Whenever the user selects an existing Area category from the top-most pop-up menu, the application automatically searches the database for Subject categories which exist for the chosen Area and places these in the Subject pop-up menu. Consequently, the user is then able to select any of these Subjects. When an existing Subject categories chosen, the application automatically generates a popup-menu for the Topic level which lists the existing Topic categories for the chosen Subject. However, whenever the user selects to enter a new Area or Subject, the lower-level pop-up menus automatically will list only the option of entering a new category. The five purpose categories for training (described in section 4.5.6) are presented in a pop-up menu from which the user can select any one. To complete the knowledge structure classification, the user selects one audience type from the final pop-up menu.

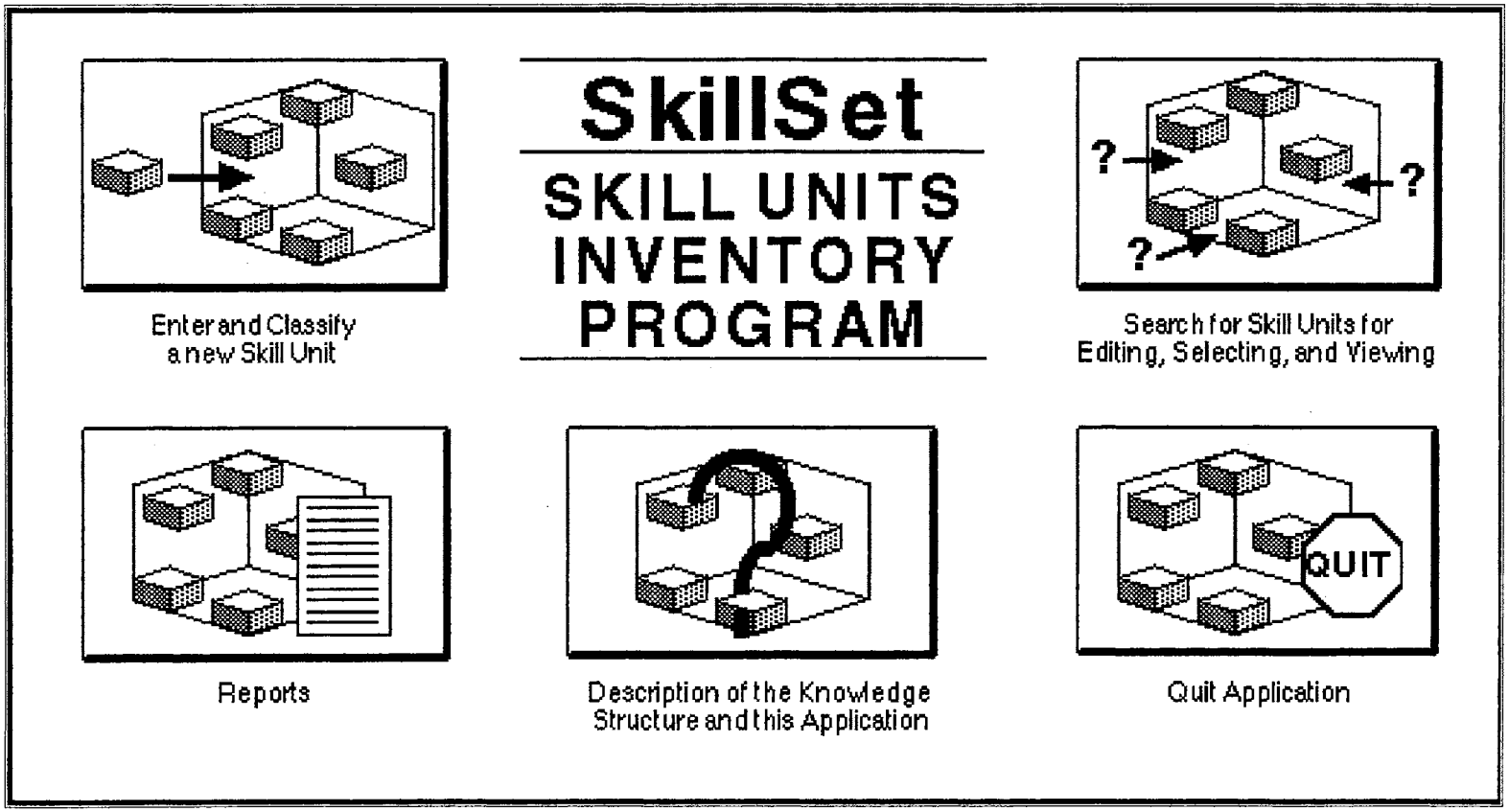


Figure 33. Main Menu Screen

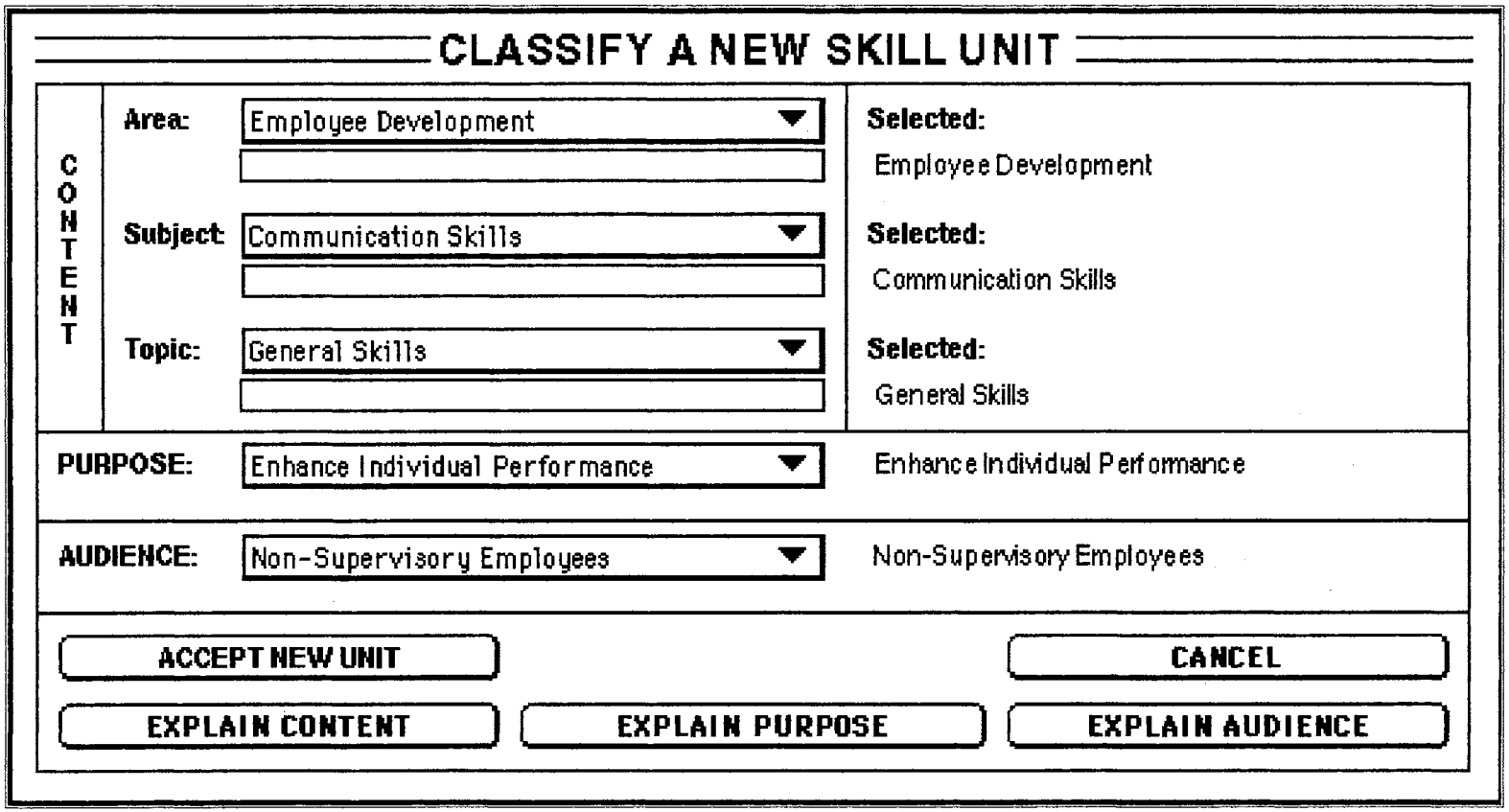


Figure 34. New Unit Classification Screen

Upon completion of the classification process, the user can either cancel the data entry process and return to the main menu, or accept the classification and proceed. When the user accepts the skill unit as classified, a unique identification number is generated for the unit.

The following data entry screens, shown in Figures 35 and 36, summarize the results of the classification process and allow the user to enter the skill unit identification information.

When the user is done entering the unit identification information, the application returns to the main menu.

The flowchart in Figure 37 shows the program structure for the option of new unit entry. In this flowchart upper-case items (such as **NEWHELP**) denote FoxPro screens and lower-case items (such as "done") denote user-choices.

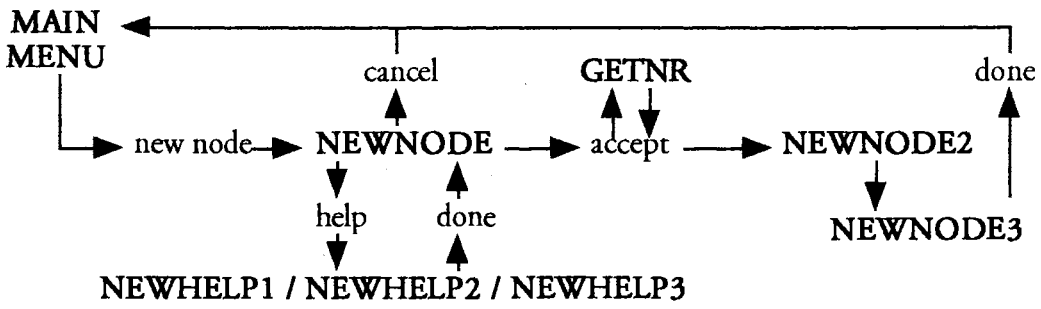


Figure 37. FoxPro Flowchart for New Unit Entry Option.

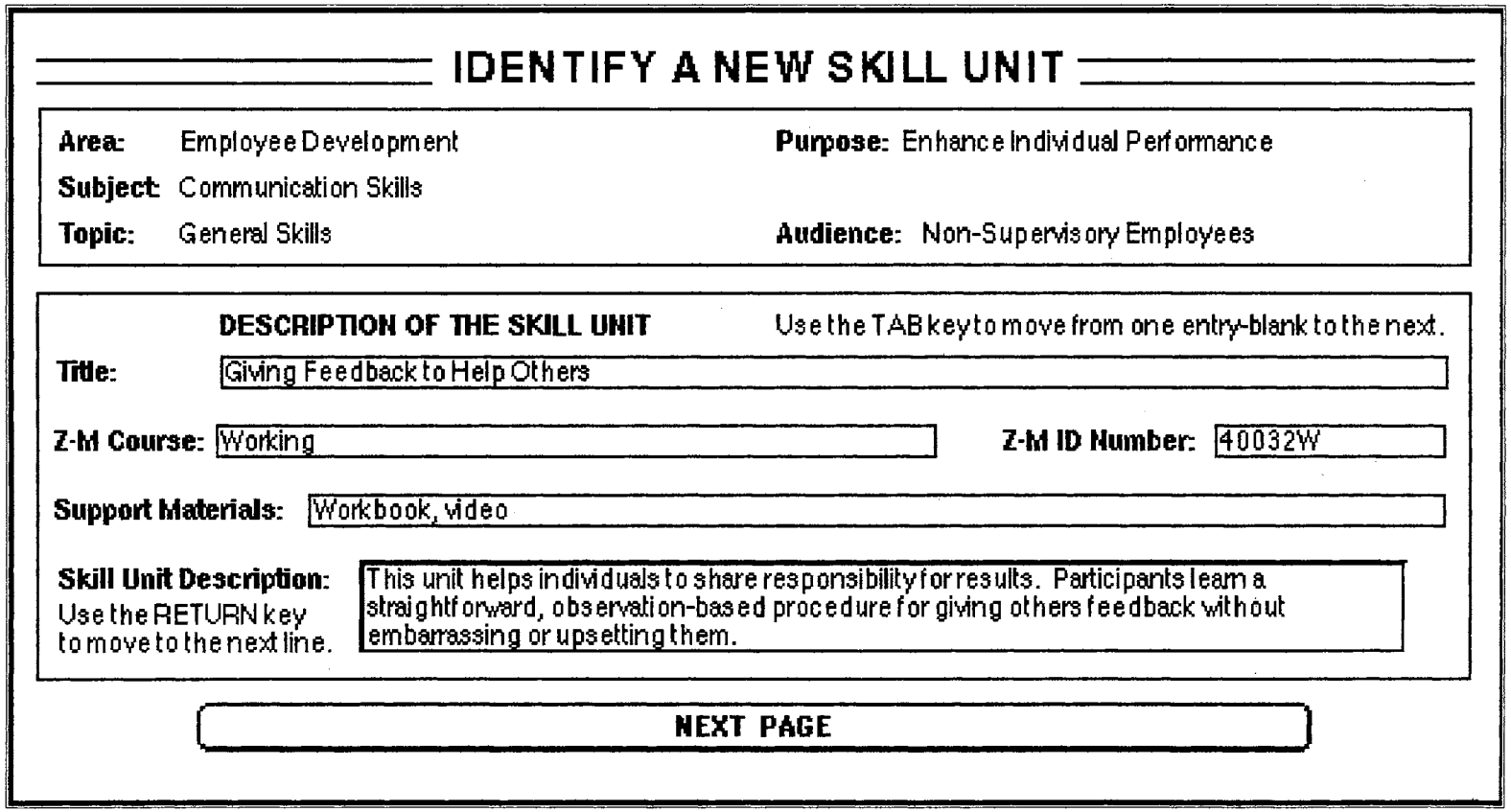


Figure 35. First New Unit Identification Screen

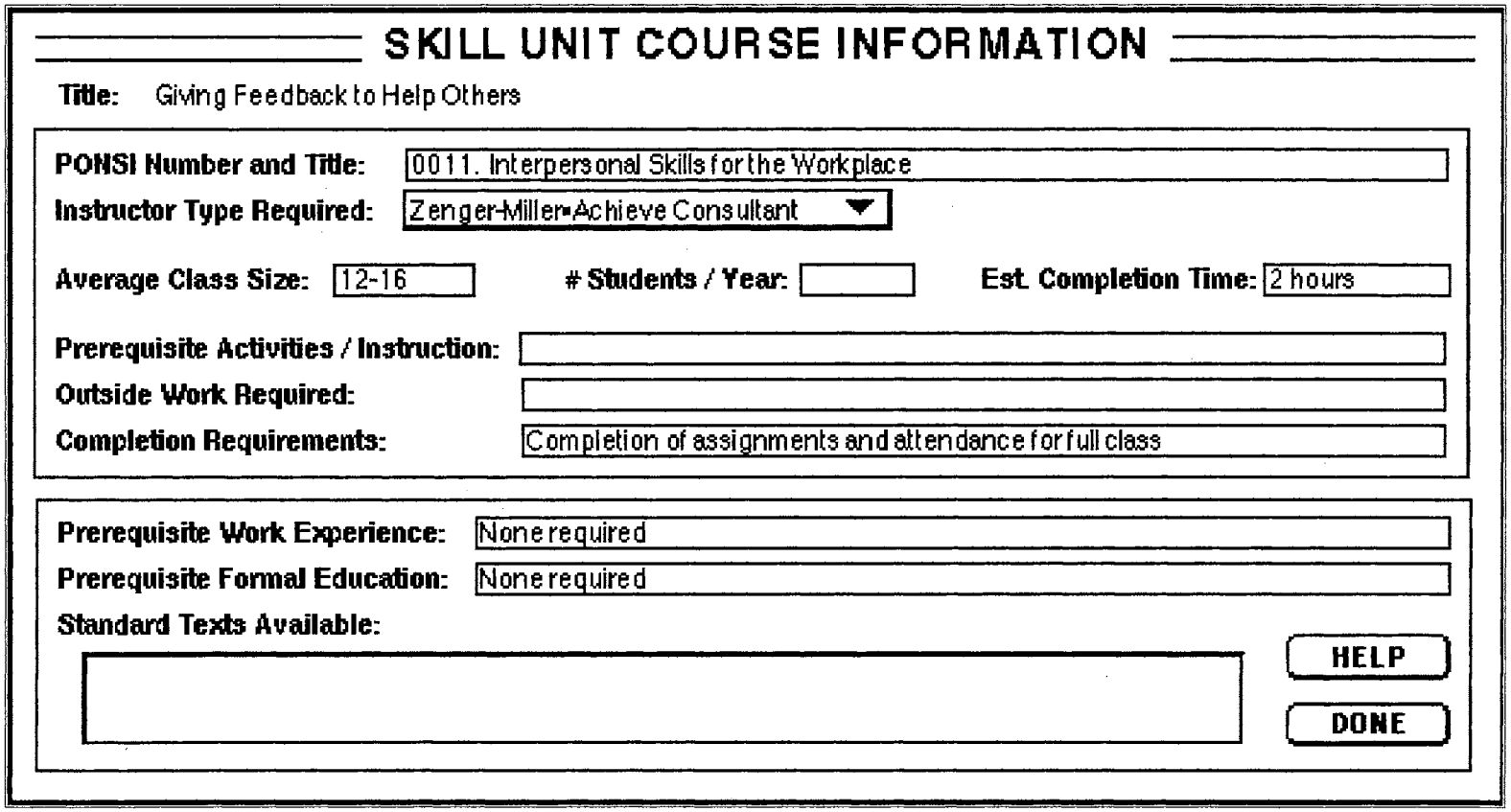


Figure 36. Second New Unit Identification Screen

A.3.4 Reports

Using the Report Selection screen shown in Figure 38, a user can create a variety of report-types. Reports can be sent either to the screen or to a printer.

The chief type of report is compiled based on user-determined reporting specifications of the Knowledge Cube. Using pop-up menus, the user can select any existing area, subject, and topic of the Content dimension of the Knowledge Cube. In a manner similar to the new node entry screen, once an Area category has been selected, the application automatically lists only those Subject categories which exist for the chosen Area. Consequently, when a Subject category has been selected, the application automatically lists only those Topic categories which exist for the chosen Subject. In addition, a particular purpose can be specified for the Purpose dimension, and a particular audience type can be selected for the Detail/Complexity dimension. In setting up the reporting criteria, however, the user is also permitted to select the "any" option for each of the dimensions to broaden the resulting report.

Upon completion of the Knowledge Cube specification, the user can select whether a short or long form of report is preferred. A short form report lists only the identification segments of the database entries which match the reporting criteria. A long form report lists both the knowledge structure and identification segments of the the database entries which match the reporting criteria. The report can be sent to the screen - which shows one database entry at a time - or to the printer. When no database entries match the user's specifications, a message is sent to the screen and no report is generated.

Finally, a separate reporting option shows all existing categories for the knowledge structure's Content dimension in a hierarchical format. No further reporting specifications are available for this report. This report, too, can be sent to either the screen or the printer.

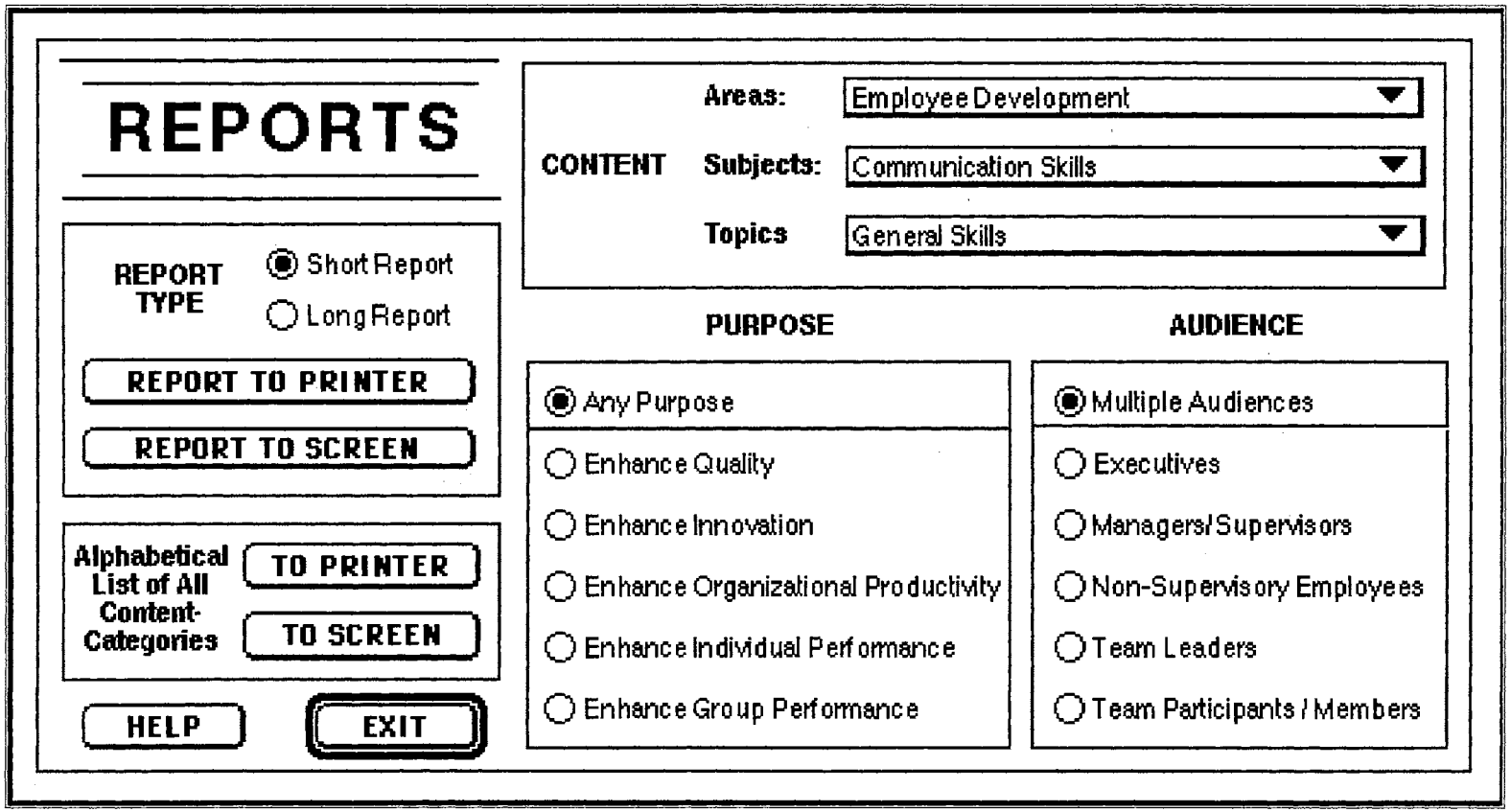


Figure 38. Report Selection Screen

The flowchart in Figure 39 shows the program structure for the reports option. In this flowchart upper-case items (such as **REPSCRN**) denote FoxPro screens, bold-faced lower-case items (such as **longrep**) denote printed reports, and plain-faced lower-case items (such as "done") denote user-choices.

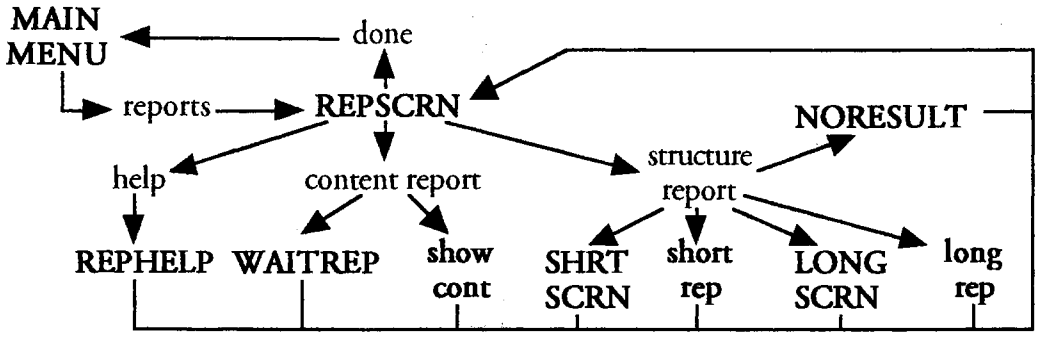


Figure 39. FoxPro Flowchart for Reporting Option.

Samples of the available report types are provided in section A.4.

A.3.5 Knowledge Structure Description

This option provides the user with a set of screens which describe the Knowledge Cube and the application's main functions in some detail. The information on these screens is based on the description of the Knowledge Cube in section 3.7.6 and is more general in nature than the information shown on the help-screens for the application's main options.

The flowchart in Figure 40 shows the program structure for the knowledge structure description option. In this flowchart upper-case items (such as **INFOMAIN**) denote FoxPro screens and lower-case items (such as "done") denote user-choices.

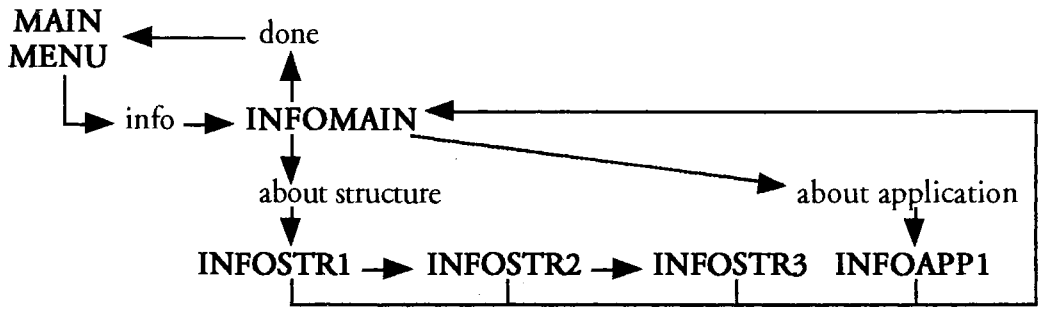


Figure 40. FoxPro Flowchart for Knowledge Structure Description Option.

A.3.6 Database Searching

The search-option on the application's Main Menu allows the user to select a single skill unit for editing, viewing, deleting, or extracting purposes. The user can perform either a knowledge structure search or a keyword search. The Search Selection Screen in shown in Figure 41.

The knowledge structure search is similar to the determination of reporting criteria in the application's reporting-option. Using pop-up menus, the user can select any existing area, subject, and topic of the Content dimension of the Knowledge Cube. In a manner similar to the new node entry screen, once an Area category has been selected, the application automatically lists only those Subject categories which exist for the chosen Area. Consequently, when a Subject category has been selected, the application automatically lists only those Topic categories which exist for the chosen Subject. In addition, a particular purpose can be specified for the Purpose dimension, and a particular audience type can be determined for the Detail-Complexity dimension. In setting up the search criteria, however, the user is also permitted to select the "any" option for each of the dimensions to broaden the search results.

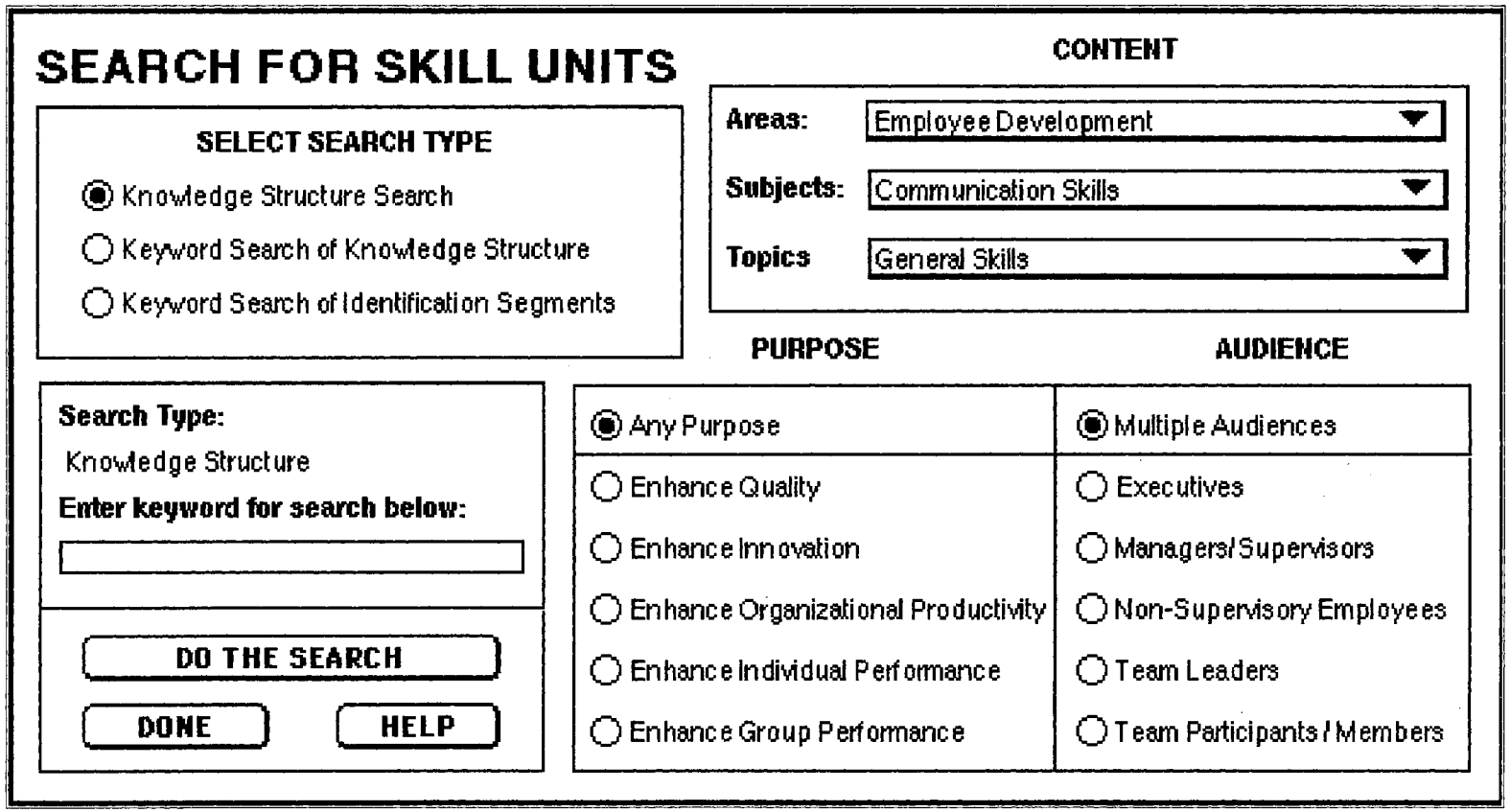


Figure 41. Search Selection Screen

Keyword searches can apply to either the knowledge structure segment or the identification segment. Upon selecting this search-type, the user enters a keyword to be used in the search. The application will then search the appropriate files for any occurrences of this keyword.

Should the search find no matching units, a message is sent to the screen and the user can modify the search criteria. Otherwise, the matching units are shown on the screen and the user can select one of the shown nodes and proceed to the selected unit options screen.

At the top of the selected unit options screen, shown in Figure 42, the application lists the title of the selected unit. Push-buttons on this screen allow the user to view the unit's database description, to edit the unit, to delete it, or to place selected skill units on the extraction list. (The view, edit, delete, and extract options are further described in subsequent sections.)

The Done-option on the selected unit options screen returns the user to the search selection screen. The user is then able to perform another search and - if desired - add more units to the extraction list, or to exit the search option and return to the application's Main Menu.

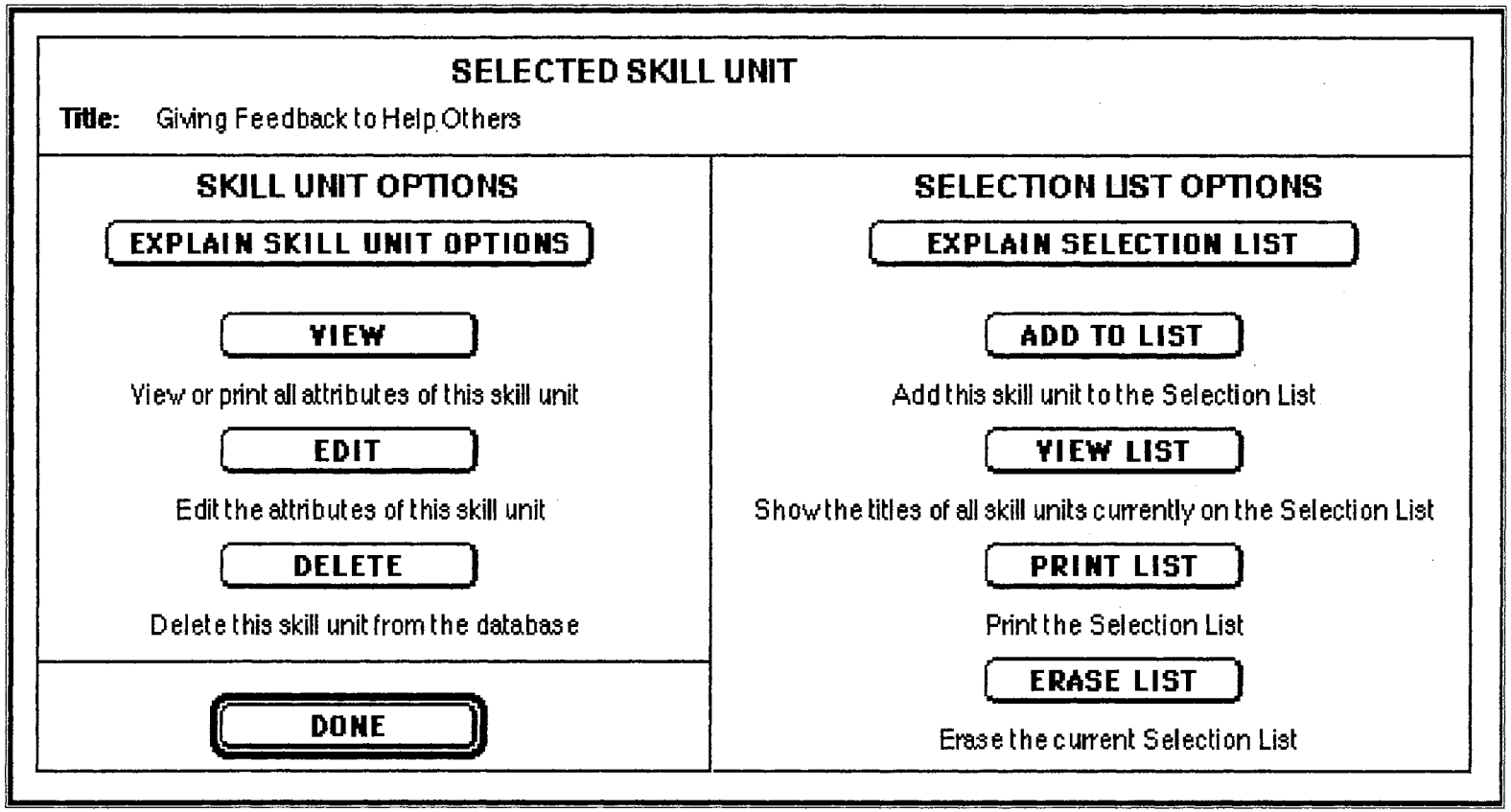


Figure 42. Selected Node Options Screen

The flowchart in Figure 43 shows the program structure for the unit search option. In this flowchart upper-case items (such as **HUNTSCR1**) denote FoxPro screens, bold-faced lower-case items (such as **prtnode**) denote printed reports, and plain-faced lower-case items (such as "done") denote user-choices.

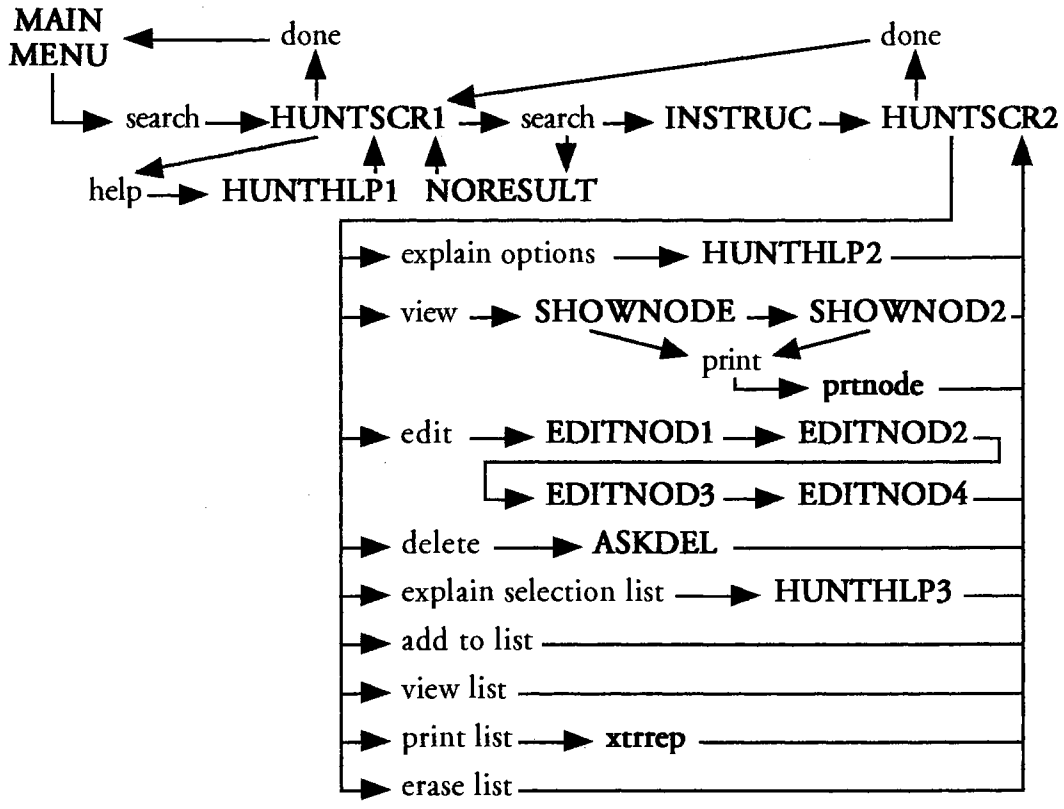


Figure 43. FoxPro Flowchart for Unit Search Option.

A.3.7 The Skill Unit Selection List

The skill unit selection list is a list on which selected units can be placed which all address a particular training objective. This list can then be printed for use by a consultant, sales-person, or client. The right-hand side of the selected unit options screen allows the user to this selection list. After adding the selected unit to the list, the user can return to the search selection screen to search for additional units to add to the selection list. (When the

user returns to the search selection screen, the selection list remains unchanged.) The list can be viewed on the screen, printed, or erased.

A.3.8 Unit Viewing

This option from the selected unit options screen shows the knowledge structure and identification segments of the selected unit. The user is given the option of printing this information. Exiting the viewing screens returns the user to the selected unit options screen. Figure 44 shows a sample Unit Viewing Screen.

A.3.9 Unit Editing

This option from the selected unit options screen allows the user to select any of the attributes of the selected skill unit, except for its identification number. The editing screens have been laid out similar to the new unit entry screens. The knowledge structure editing screen allows the user to edit the knowledge structure attributes of the selected unit. At first, the upper pop-up menu lists all existing Area categories. In a way similar to the new unit entry screen, once an Area category has been selected, the application automatically lists only those Subject categories which exist for the chosen Area. Consequently, when a Subject category has been selected, the application automatically lists only those Topic categories which exist for the chosen Subject. However, the user is also able to specify new category headers at any of these levels. The editing of the Purpose and Audience (Detail/Complexity) categories is similar to the new node entry screen.

Upon completion, the user can choose to accept and save the changes or to cancel editing the knowledge structure segment. In the latter case, any changes made are not saved.

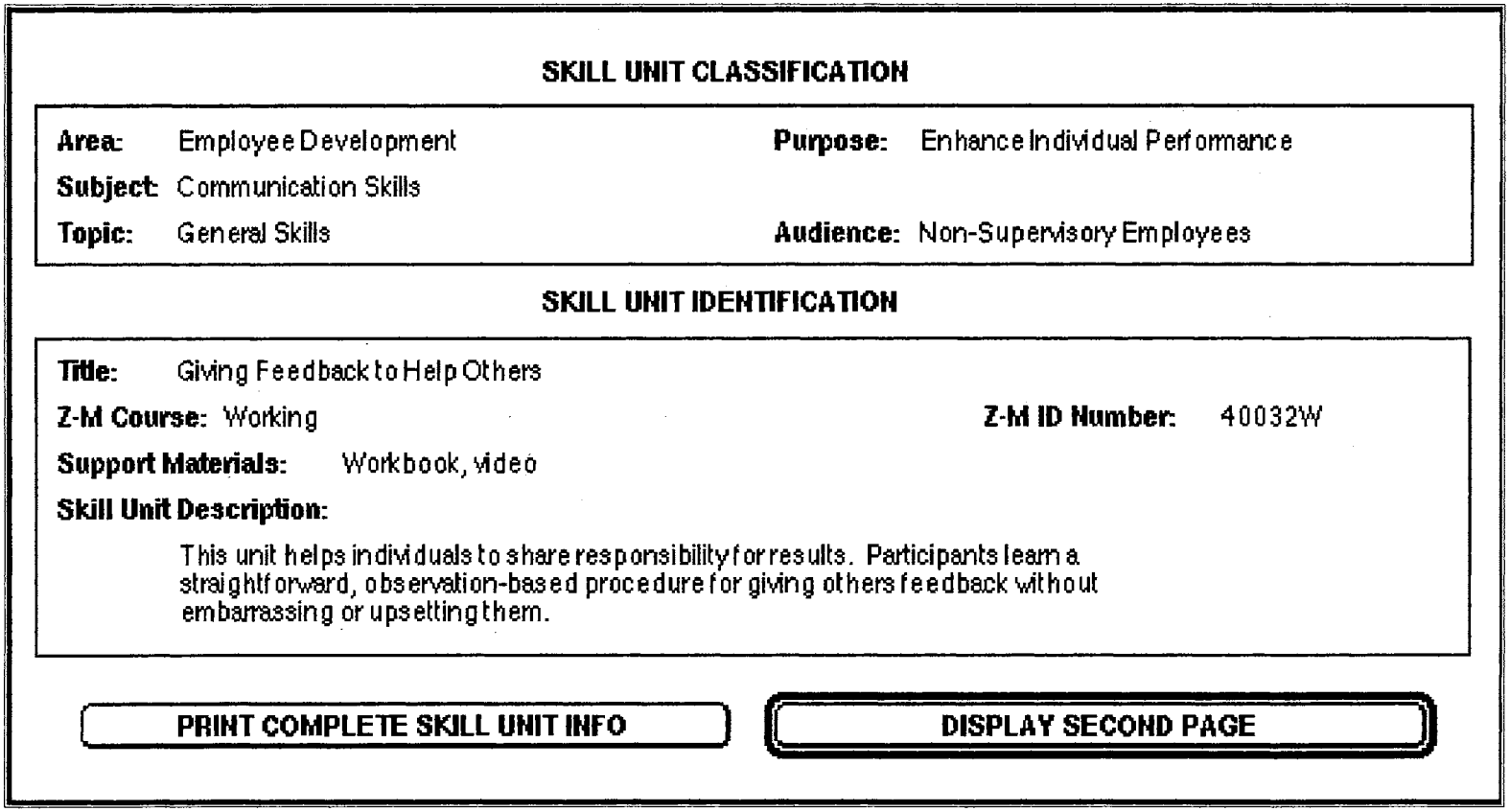


Figure 44. Sample Skill Unit Viewing Screen

The application consequently shows the identification segment editing screen, which allows the user to change any of the identification attributes of the selected unit. Below each attribute's initially empty edit box, the current value of the attribute is shown. Upon completion of the editing, the user can once again choose to accept and save the changes or to cancel the editing and not save any changes made. Either way of exiting this second editing screen returns the user to the selected node options screen. A sample editing screen in shown in Figure 45.

A.3.10 Unit Deletion

This option from the selected unit options screen allows the user to permanently erase the skill unit from the database. When choosing this option, the user is asked to reconfirm or cancel this action, since such a deletion cannot be undone. Upon completion, the user is returned to the selected unit options screen.

A.3.11 Quit Application

Selecting the Quit option from the application's main menu closes all database files and terminates the application's execution.

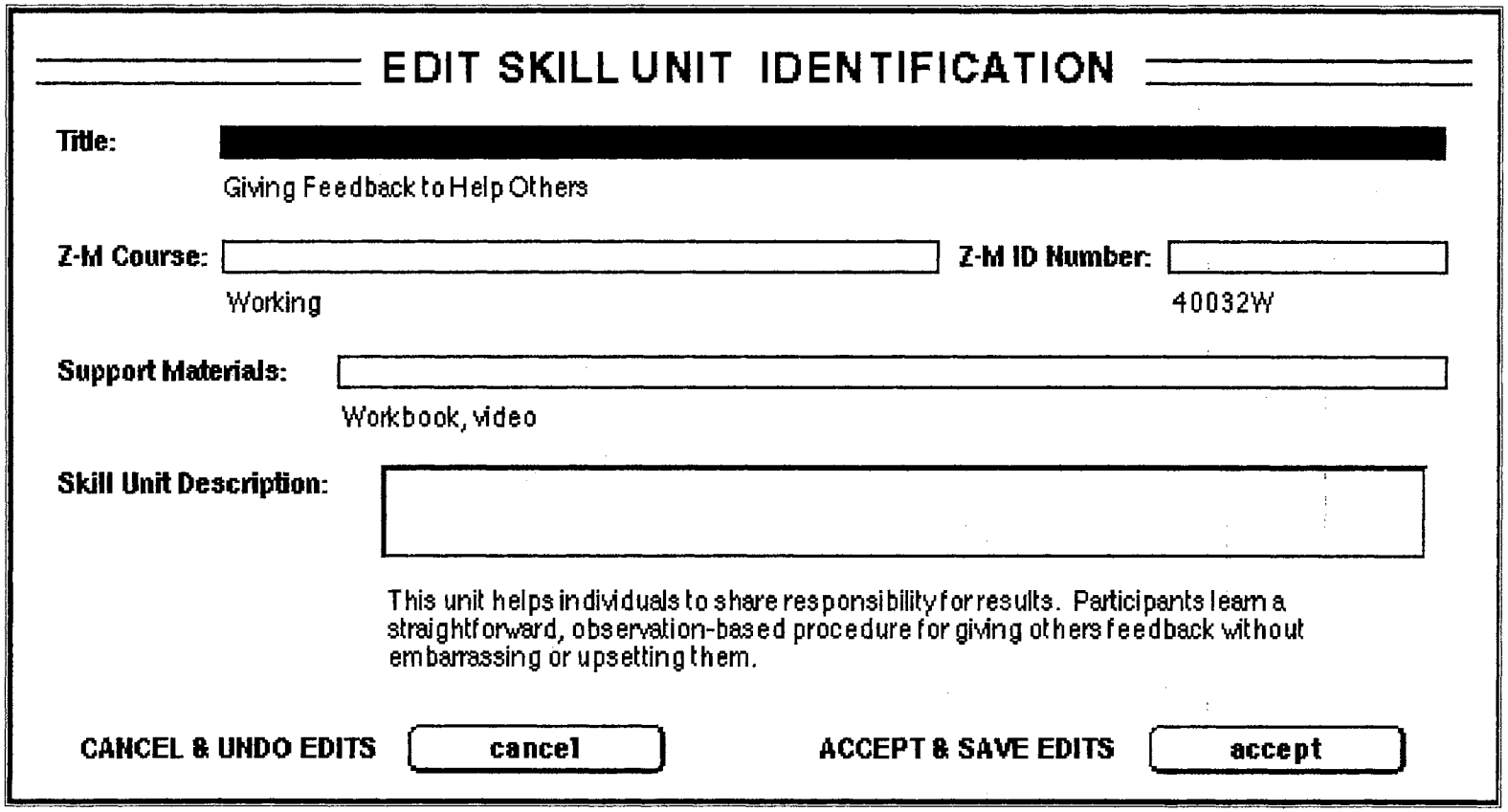


Figure 45. Sample Skill Unit Editing Screen

A.4 Application Reports

The following five types of printed reports are available, each permitting a different view of both the knowledge structure and the database contents:

- **Content Categories Report**: a hierarchical list of all existing areas, subjects, and topics which make up the Content dimension in the database, shown in figure 46.
- **Short-Form Report**: a listing of the identification segments of all skill units which match the user-specified reporting criteria, shown in figure 47.
- **Long-Form Report**: a listing of the knowledge structure and identification segments of all skill units which match the user-specified reporting criteria, shown in figure 48.
- **Single Node Report**: the knowledge structure and identification segments of the single skill unit which the user selected using the search selection screen, shown in figure 49.
- **Selection List Report**: a listing of the identification segments of the skill units which the user added to the selection list, shown in figure 50.

Samples of these five reports are shown on the following pages.

SKILL UNITS INVENTORY PROGRAM Printed on: 11/14/94

CURRENTLY AVAILABLE CONTENT CATEGORIES

Areas	Subjects	Topics
Employee Development	Communication Skills	Communicating with Superiors
		General Skills
		Working With Others
	Productive Work Skills	Empowerment
		Working With Others
Managerial Development	Developing the Organization	Change & Innovation
	Interpersonal Skills	Basic Skills
		Organizational Relationships
	Management Support Role	Supporting Groups
		Supporting Individuals
	Problem Solving	Problem Solving Fundamentals
		Problem Solving by Groups
Teamwork	Team Leadership	Change & Innovation
		Facilitating Teamwork
		Team Building
		Team Goals
	Team Participation	Individual Contributions
		Motivation for Teams
		Working as a Team
Total Quality Management	Committing to Quality	Maintaining Quality
		Preparing for Quality
	Performing Quality	Quality to the Customer
		Quality-focused Work

Figure 46. Content Categories Report

SKILL UNITS INVENTORY PROGRAM **Printed on: 11/14/94**

SEARCH CRITERIA

Area: Employee Development **Purpose:** any
Subject: Communication Skills
Topic: Working With Others **Audience:** any

SKILL UNIT DESCRIPTION

Title: Resolving Issues with Others
Z-M Course Working **Z-M ID Number** 40038W
Instructor Type Required: **Est. Completion Time:** 2 hours
Completion Requirements: Completion of assignments and attendance for full class
Support Materials: Workbook, video

SKILL UNIT DESCRIPTION

Title: Participating in Group Meetings
Z-M Course Working **Z-M ID Number** 40036W
Instructor Type Required: **Est. Completion Time:** 1h 45min
Completion Requirements: Completion of assignments and attendance for full class
Support Materials: Workbook, video

Figure 47. Short-Form Report

SKILL UNITS INVENTORY PROGRAM **Printed on: 11/14/94**

SEARCH CRITERIA

Area:	Employee Development	**Purpose:**	any
Subject:	Communication Skills		
Topic:	Working With Others	**Audience:**	any

SKILL UNIT DESCRIPTION

Area:	Employee Development	**Purpose:**	Enhance Individual Performance
Subject:	Communication Skills		
Topic:	Working With Others	**Audience:**	Non-Supervisory Employees

Title: Resolving Issues with Others

Z-M Course Working **Z-M ID Number** 40038W

Instructor Type Required: **Est. Completion Time:** 2 hours

Completion Requirements: Completion of assignments and attendance for full class

Support Materials: Workbook, video

SKILL UNIT DESCRIPTION

Area:	Employee Development	**Purpose:**	Enhance Group Performance
Subject:	Communication Skills		
Topic:	Working With Others	**Audience:**	Non-Supervisory Employees

Title: Participating in Group Meetings

Z-M Course Working **Z-M ID Number** 40036W

Instructor Type Required: **Est. Completion Time:** 1h 45min

Completion Requirements: Completion of assignments and attendance for full class

Support Materials: Workbook, video

Figure 48. Long-Form Report

SKILL UNITS INVENTORY PROGRAM **Printed on:** 11/14/94

SKILL UNIT CLASSIFICATION

Area: Employee Development **Purpose:** Enhance Individual Performance
Subject: Communication Skills
Topic: Working With Others **Audience:** Non-Supervisory Employees

SKILL UNIT IDENTIFICATION

Title: Resolving Issues with Others
Z-M Course: Working **Z-M ID Number:** 40038W
Support Materials: Workbook, video
Skill Unit Description: In this unit, participants are provided a formula for confronting problems with peers and for generating a mutually acceptable action plan.

SKILL UNIT COURSE INFORMATION

PONSI Number & Title: 0011. Interpersonal Skills for the Workplace
Instructor Type Required:
Average Class Size: 12-16 **# Students / Year:** 18000 **Est. Completion Time:** 2 hours
Prerequisite Activities / Instruction:
Outside Work Required:
Completion Requirements: Completion of assignments and attendance for full class

Prerequisite Work Experience: None required
Prerequisite Formal Education: None required
Standard Texts Available:

Figure 49. Single Node Report

SKILL UNITS INVENTORY PROGRAM **Printed on: 11/14/94**

LIST OF SELECTED SKILL UNITS

Title: Resolving Issues with Others
Z-M Course: Working **Z-M ID Number:** 40038W
Instructor Type Required:
Support Materials: Workbook, video
Completion Requirements: Completion of assignments and attendance for full class

Title: Participating in Group Meetings
Z-M Course: Working **Z-M ID Number:** 40036W
Instructor Type Required:
Support Materials: Workbook, video
Completion Requirements: Completion of assignments and attendance for full class

Figure 50. Selection List Report

A.5 Application Summary

The following are all elements which are part of the application prototype.

Type	Name	Description
Files	Idnr	Contains sequence number for next database entry.
	Idseg	Contains skill unit identification segment.
	Knstruc	Contains skill unit knowledge structure segment.
	Xlist	Contains selection list pointers.
Reports	Longrep	Long-form knowledge structure report.
	Prtnode	Complete information on a single skill unit.
	Shortrep	Short-form knowledge structure report.
	Showcont	Listing of all existing content-categories.
	Xtrrep	Skill units on the selection list.
Menus	Menubar	Removes most pull-down menu options.
Screens	Askdel	Asks user if the skill unit really is to be erased.
	Editnod1	Used for editing skill unit's knowledge structure fields.
	Editnod2	Used for editing skill unit's identification fields.
	Editnod3	Used for editing skill unit's course information fields.
	Editnod4	Used for editing skill unit's course information fields.
	Getnr	Obtains identification number for a new skill unit.
	Hnthlp1	Describes how to search for a single skill unit.
	Hnthlp2	Describes options for a single skill unit.
	Hnthlp3	Describes selection list options.
	Hntscrn1	Lets user define the search for a single skill unit.

Type	Name	Description
Screens	Hntscrn2	Provides options following search for a single skill unit.
	Infoapp1	Describes the application prototype.
	Infomain	Provides access to information screens.
	Infostr1	Describes content dimension of the knowledge structure.
	Infostr2	Describes purpose dimension of the knowledge structure.
	Infostr3	Describes audience dimension of the knowledge structure.
	Instruc	Helps user select a single skill unit during a search.
	Longscrn	Long-form knowledge structure report on the screen.
	Mainmenu	Provides access to the application's functions.
	Newhelp1	Describes content dimension for data entry or editing.
	Newhelp2	Describes purpose dimension for data entry or editing.
	Newhelp3	Describes audience dimension for data entry or editing.
	Newnode	Data entry of knowledge structure for new skill unit.
	Newnode2	Data entry of unit identification for new skill unit.
	Newnode3	Data entry of course information for new skill unit.
	Noresult	Tells user that search or report contains no skill units.
	Rephelp	Describes how to define a report.
	Repscrn	Allows user to define a report.
	Shownod2	Shows skill unit's course information fields.
	Shownode	Shows skill unit's structure and identification fields.
	Shrtscrn	Short-form knowledge structure report on the screen.
	Waitrep	Explains the use of the content report on the screen.

APPENDIX B – RESEARCH INSTRUMENTS

This appendix contains samples of the measurement instruments used during the knowledge organization and retrieval activities of the case study. The following are brief descriptions of the instruments in the order in which they appear in this appendix:

- **Knowledge Organization Questionnaire**. The satisfaction analysis questionnaire given to the study's participants after completing the knowledge organization activity.

- **Knowledge Retrieval Questionnaire**. The satisfaction analysis questionnaire given to the study's participants after completing the knowledge retrieval activity.

KNOWLEDGE ORGANIZATION QUESTIONNAIRE

Name: _____

Please answer the following questions based on your experiences during the task you have just completed. For the scaled questions, select the answer on the scale which most closely coincides with your opinion. The questions cover the following three areas: the FoxPro application you worked with, the three-dimensional knowledge structure you used, and the task you performed.

The FoxPro Application

1. The computer-application was easy to use.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

2. The help-screens provided by the application were useful and informative.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

3. It was clear what types of input the application required.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

4. The reports generated by the application were useful.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

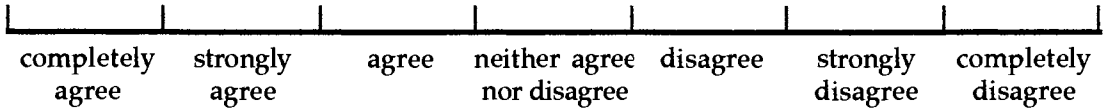
5. The application's screen-layouts were clear.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

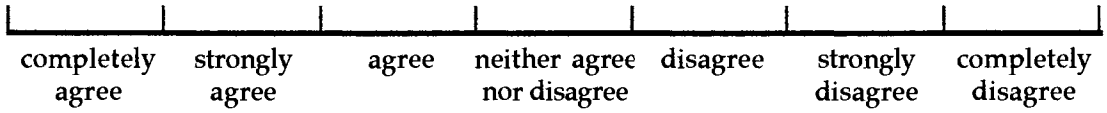
6. How might this application be improved?

The Knowledge Structure

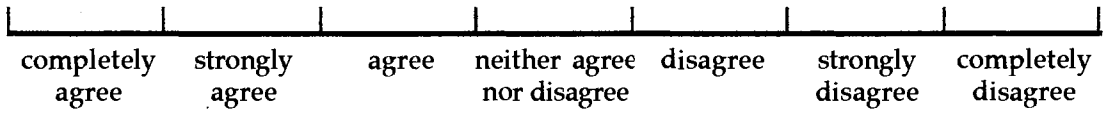
1. The knowledge structure appears to be a **useful** method for organizing the skill units.



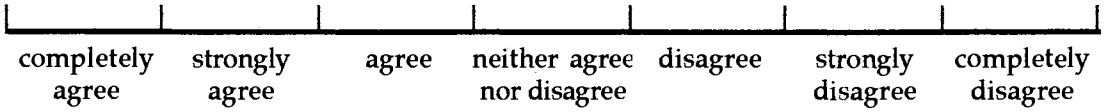
2. The knowledge structure appears to be a **clear** method for organizing the skill units.



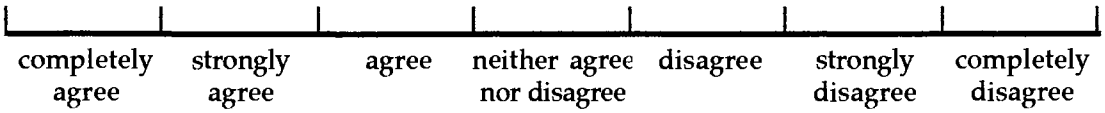
3. The knowledge structure appears to be a **sensible** method for organizing the skill units.



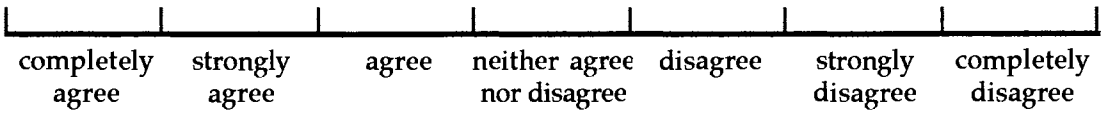
4. The knowledge structure appears to be a **complete** method for organizing the skill units.



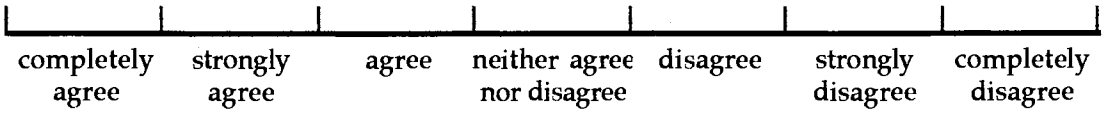
5. The 3-level content-dimension is useful when organizing the skill units.



6. Having a purpose-aspect is useful when organizing the skill units.



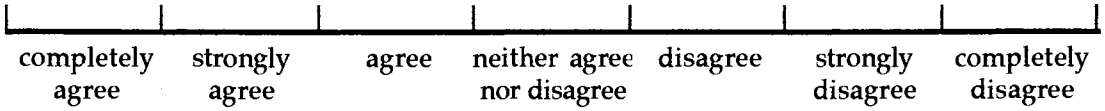
7. The 6-level audience dimension is useful when organizing skill units.



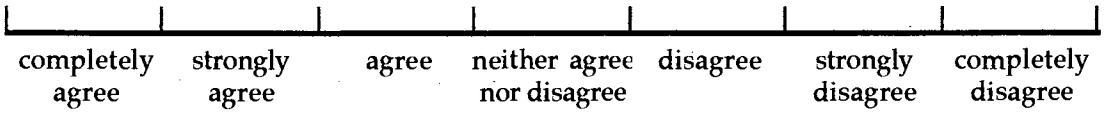
8. How might this knowledge structure be improved?

The Task

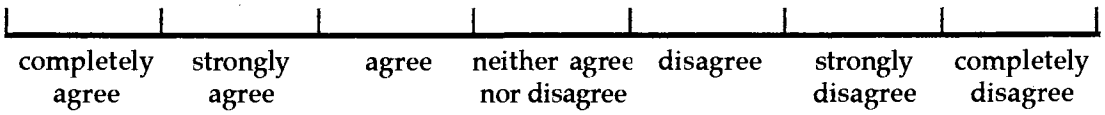
1. It was quite easy to determine how to classify each skill unit.



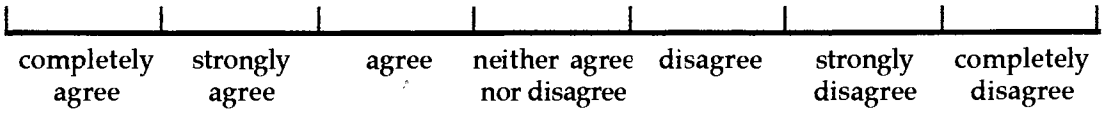
2. Each skill unit fit neatly into a single classification.



3. I felt quite comfortable classifying the skill units.



4. I would use this application again for the task of classifying skill units.



Thank You !

KNOWLEDGE RETRIEVAL QUESTIONNAIRE

Name: _____

Please answer the following questions based on your experiences during the task you have just completed. For the scaled questions, select the answer on the scale which most closely coincides with your opinion. The questions cover the following three areas: the FoxPro application you worked with, the three-dimensional knowledge structure you used, and the task you performed.

The FoxPro Application

1. The computer-application was easy to use.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

2. The help-screens provided by the application were useful and informative.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

3. It was clear what types of input the application required.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

4. The reports generated by the application were useful.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

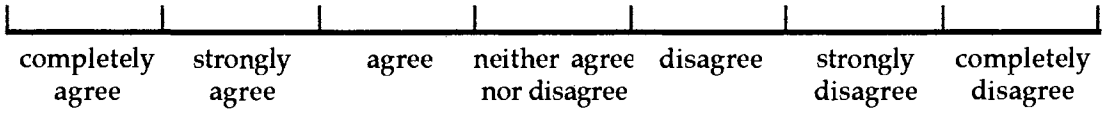
5. The application's screen-layouts were clear.

completely agree	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	completely disagree

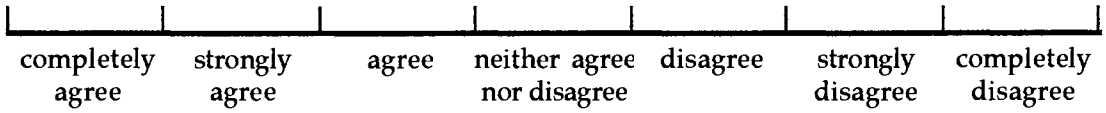
6. How might this application be improved?

The Knowledge Structure

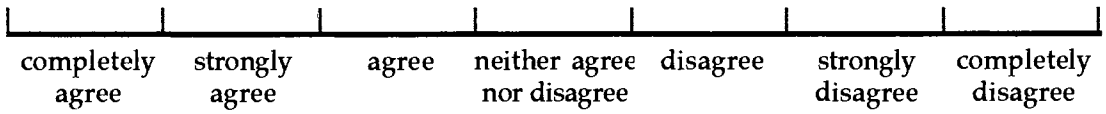
1. The knowledge structure appears to be a **useful** method for organizing the skill units.



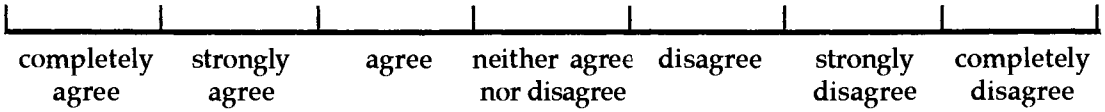
2. The knowledge structure appears to be a **clear** method for organizing the skill units.



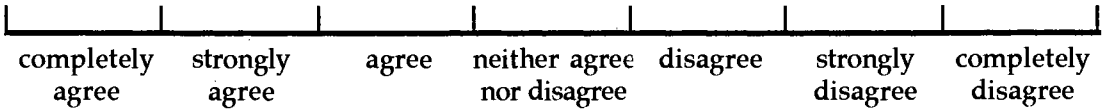
3. The knowledge structure appears to be a **sensible** method for organizing the skill units.



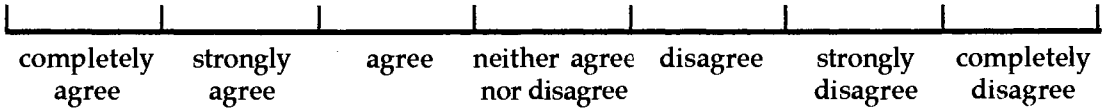
4. The knowledge structure appears to be a **complete** method for organizing the skill units.



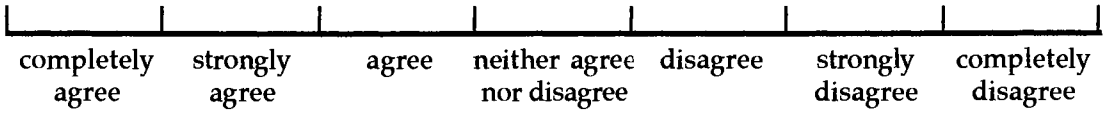
5. The 3-level content-dimension is useful when organizing the skill units.



6. Having a purpose-aspect is useful when organizing the skill units.



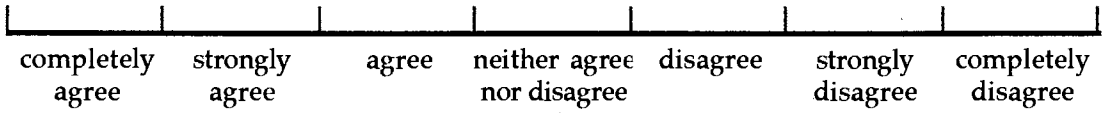
7. The 6-level audience dimension is useful when organizing skill units.



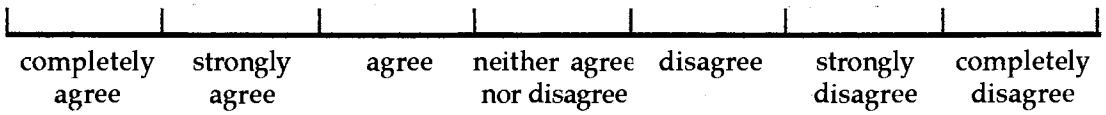
8. How might this knowledge structure be improved?

The Task

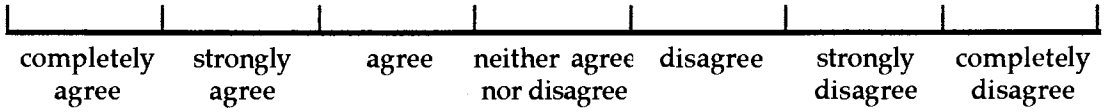
1. The training criteria provided were quite clear.



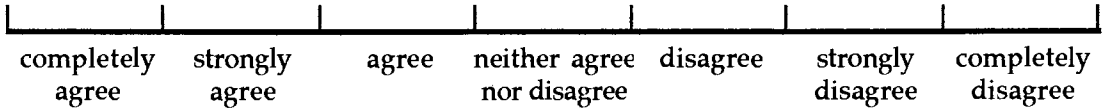
2. It was easy to find one or more skill units which fit the provided training criteria.



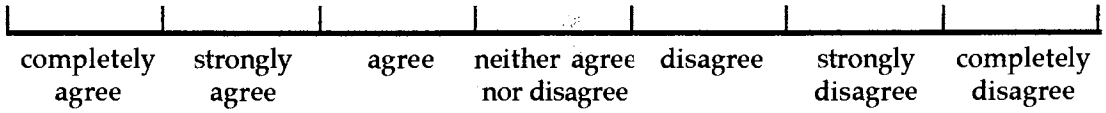
3. I felt quite comfortable selecting the skill units.



4. I thought the process of retrieving the skill units was effective.



5. I would use this application again for the task of retrieving the skill units.



Thank You !

APPENDIX C – PROTOCOL INSTRUMENTS

This appendix contains samples of the protocol instruments used during the knowledge organization and retrieval activities of the case study. The following are brief descriptions of the instruments in the order in which they appear in this appendix:

- **Experiment Activity Codes**. Codes used by the researcher to log the activities of the participants during the study.
- **Experiment Log-Sheet**. Sheet on which the researcher logged the activities of the participants during the study.
- **Summary Sheet - Knowledge Organization**. A handout given to the study's participants at the start of the knowledge organization activity which provided them with an overview of the activity.
- **Training Guide - Knowledge Organization**. A script for the researcher to follow when explaining and starting up the knowledge organization activity to the study's participants.
- **Three-Dimensional Knowledge Structure**. A handout given to the study's participants at the start of the knowledge organization activity which provided them with a graphical overview of the knowledge structure.
- **Knowledge Structure Helpsheet**. A handout given to the study's participants at the start of the knowledge organization activity which detailed the dimensions and categories of the knowledge structure.
- **Skill Unit Example**. A skill-unit description used by the researcher to demonstrate the classification and entry of a new skill unit to the study's participants. The knowledge structure classification used for this skill unit is shown at the bottom of this page.
- **Skill Unit #1 - #5**. The five skill unit descriptions used by the study's participants for the knowledge organization activity.

- **Summary Sheet - Knowledge Retrieval**. A handout given to the study's participants at the start of the knowledge retrieval activity which provided them with an overview of the activity.
- **Training Guide - Knowledge Retrieval**. A script for the researcher to follow when explaining and starting up the knowledge retrieval activity to the study's participants.
- **Business Problem 1 - 4**. The four case problems used by the study's participants for the knowledge retrieval activity.

EXPERIMENT ACTIVITY CODES

• START	starting time
• DONE	ending time
• MAIN	go to main menu
• CANCEL	cancel previous selection
• HELP	get help-screen for current action
• QUES	ask questions
• QUIT	exit the application
• NEW	enter a new unit into the database
• REPMENU	go to reports-menu
• CONT-S	display content-report on the screen
• CONT-P	send content-report to the printer
• SHORT-S	display short-form report on the screen
• SHORT-P	send short-form report to the printer
• LONG-S	display long-form report on the screen
• LONG-P	send long-form report to the printer
• STR-INFO	go to info-screens on the knowledge structure
• APP-INFO	go to info-screens on the application
• SRCHMENU	go to search-menu
• STR-SRCH	perform knowledge structure search
• STR-KEY	perform keyword search of knowledge structure
• ID-KEY	perform keyword search of identification segments
• VIEW	view selected unit
• VIEW-P	print the selected unit
• EDIT	edit the selected unit
• DELETE	delete the selected unit
• ADD-LIST	add the selected unit to the selection list
• ERASE-LIST	erase the selection list
• LIST-S	display the selection list on the screen
• LIST-P	send the selection list to the printer

Figure 51. Experiment Activity Codes

EXPERIMENT LOG-SHEET

Subject ID: _____ Load / Extract Page #: ____

CODE	COMMENT

Figure 52. Experiment Log Sheet

SUMMARY SHEET – KNOWLEDGE ORGANIZATION

1. Introduction

2. The Purpose of Knowledge Organization

3. What is Knowledge?

4. Explanation of the Activity

5. Explanation of the Knowledge Structure

6. Explanation of the SkillSet Application

7. Explanation of the Task

8. Performing the Task

9. Knowledge Organization Questionnaire

10. Conclusion

TRAINING GUIDE - KNOWLEDGE ORGANIZATION

1. Preparation

Copy the initial database for the loading experiment from disk to computer.

Start up FoxPro and the SkillSet application.

2. Introduction / Purpose

Welcome the participant and thank him/her for taking the time to participate in the study.

Introduce myself, the doctoral student, working on a dissertation project on knowledge organization.

What I am doing for my dissertation is to try out a new method for organizing knowledge. The knowledge we're going to organize is made up of the skill units developed by Zenger-Miller. The purpose of this study is to see whether people in the workplace find this new method useful and effective.

Ask participant's name, job title, job description, and experience with computers.

3. Explain Knowledge

The topic of the dissertation is knowledge. What is knowledge? It is information, expertise, experience, processes, procedures, etc., and organizations are increasingly trying to capture it and use it more effectively.

What I am particularly interested in is how organizations can organize the knowledge they acquire and use. Finding the knowledge that you have is essential to using it when you need it. Organizations are of course trying to use computers to keep track of their knowledge, but most knowledge does not fit easily into traditional databases. New organization methods must be found.

For example, libraries arrange materials according to the Dewey Decimal Classification system, but you don't use this system to find materials. Rather, you use a keyword search. This may lead to two problems:

- Not finding the information you need.
- Finding information that does not fit your needs.

4. Explain the Activity Itself

What you will do is to use some of Zenger-Miller's skill units and place them into a database using a computerized knowledge management system called SkillSet. This means that you will categorize and evaluate the skill units as to what they are about and what they can be used for. You will be observed as to what you do and how you use the SkillSet application and will be asked after you are done how you feel about this new knowledge organization method.

5. Explain the Knowledge Structure

The knowledge organization method that you will be using is three-dimensional. Think of it as moving around in a building, trying to find the right floor, the right corridor, and the right office. In the knowledge organization method, you will insert a skill unit according to three different dimensions, which are three different ways of describing the skill units. These three dimensions are: **[Show picture]**

- **Content** - this is a broad description of the discipline into which the multimedia fits. It has three levels: area, subject, and discipline. These are described in some more detail on the help-sheet.
- **Purpose** - these are broad five purposes for which Zenger-Miller develops training materials. Any training material will fit into at least one of these five.
- **Audience** - this describes who the training materials are intended for. For example, materials developed for people involved in teamwork are not always appropriate to, say, corporate executives.

Is this method clear to you? Do you have any questions at this time?

6. Explain the Application

Show the participant how to use the SkillSet application for the task. From the main menu, demonstrate the following options:

- Enter a new skill unit (Giving Feedback to Help Others).
- Show the content-listing report and the knowledge-structure report.
- Show the information-screens.
- We'll save the searching for next time.

Is this application clear to you? Do you have any questions at this time?

7. Explain the Task in More Detail

Here is what you'll do. You will be given descriptions of some skill units at Zenger-Miller. It is then up to you to classify them according to the knowledge organization method, using the SkillSet application.

When classifying, you may use use some of the Content category names which already exist in the database (like I did when I entered the example). Or you may enter new category names when you feel the knowledge does not fit into existing categories.

Please remember that there is no right or wrong way. SkillSet is flexible enough to accommodate various styles and approaches of users. Please classify the materials the way you think is best.

If at any point you have a question, please feel free to ask.

8. Provide the Task & Observe

Note the participant's actions on the log-sheets. Being there to answer questions provides a good excuse to remain in the room with the subject and observe him or her.

9. Questionnaire

Thank you for doing this. You did a great job. Now please fill out this questionnaire on which you rate your opinions about what you have just done.

After filling out the questionnaire, do you have anything to add on what you think of this organization method for skill units?

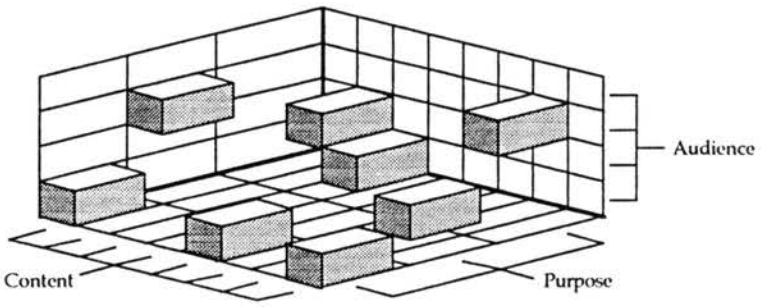
10. Prepare for Next Part

I will see you again soon for the second part of the study. In the second part, you will use the application to retrieve materials from the database. I've separated this second part from the first activity so that you have some time to consider the knowledge organization method.

11. End Session

Copy final state of database after the experiment from computer to the disk.

THREE-DIMENSIONAL KNOWLEDGE STRUCTURE



CONTENT: A hierarchical breakdown of what the knowledge is about.

PURPOSE: The use to which the knowledge is to be put.

AUDIENCE: People for whom the training is intended.

Figure 53. Three-Dimensional Knowledge Structure

KNOWLEDGE STRUCTURE HELPSHEET

CONTENT A hierarchical breakdown of what the knowledge is about.

Area: General disciplines for which knowledge exists. Areas can be defined broadly.

Subject: Within an area, different subjects may be identified which cover a somewhat more specific discipline or specialty.

Topic: A specific concept within a given subject or area of expertise.

PURPOSE The use to which the knowledge is to be put.

Enhance Quality: this relates to the issues of customer orientation, product quality, and process quality.

Enhance Innovation: this relates to the issues of organizational flexibility and adaptability, and the enhancement of organizational culture.

Enhance Organizational Productivity: this relates to the objectives of overall organizational efficiency, business process re-engineering, downsizing, delayering, and overall organizational competitiveness.

Enhance Individual Performance: this relates to the issues of employee performance and empowerment, managerial performance, interpersonal skills, and communication skills.

Enhance Group Performance: this relates to the issues of team work, team leadership, and team interactions and intercommunications.

AUDIENCE People for whom the training is intended.

Executives: top-level people in the organization, who (among other things) deal with the organization's long-term strategy.

Managers/Supervisors: People in management or supervisory positions who are generally overseeing production-level or administrative work.

Non-Supervisory Employees: individual contributors performing production-level or administrative work.

Team Leaders: people leading permanent or temporary work groups, such as multidisciplinary teams.

Team Participants / Members: people participating in permanent or temporary work groups.

Multiple Audiences: the skill unit is appropriate to more than one of the above audiences.

Figure 54. Knowledge Structure Helpsheet

SKILL UNIT EXAMPLE

Title: Giving Feedback to Help Others

Zenger-Miller Course: Working

Zenger-Miller Identification Number: 40032W

Support Materials: Workbook, video

Short Skill Unit Description:

The course helps individuals to share responsibility for results. Participants learn a straightforward, observation-based procedure for giving others feedback without embarrassing or upsetting them.

PONSI Number & Title: 0011. Interpersonal Skills for the Workplace

Instructor Type Required:

Average Class Size: 12-16

Number of Students per Year:

Estimated Completion Time: 2 hours

Prerequisite Activities or Instruction: None

Outside Work Required: None

Completion Requirements: Completion of assignments and attendance for full class

Prerequisite Work Experience: None required

Prerequisite Formal Education: None required

Standard Texts Available:

Area:	Employee Development	**Purpose:**	Enhance Individual Performance
Subject:	Communication Skills		
Topic:	General Skills	**Audience:**	Non-Supervisory Employees

SKILL UNIT # 1

Title: Clarifying Team Roles and Responsibilities

Zenger-Miller Course: FrontLine Leadership

Zenger-Miller Identification Number: 70043FLL

Support Materials: Workbook

Short Skill Unit Description:

Participants will learn a series of strategies to use when launching a new team effort or revitalizing an existing team. Team leaders will describe team results and standards, and determine team member roles and responsibilities.

PONSI Number & Title: 0008. Building Successful Teams

Instructor Type Required:

Average Class Size: 12-16

Number of Students per Year:

Estimated Completion Time: 4 hours

Prerequisite Activities or Instruction: None

Outside Work Required: None

Completion Requirements: Full attendance, including any supplemental options

Prerequisite Work Experience: None required

Prerequisite Formal Education: None required

Standard Texts Available:

SKILL UNIT # 2

Title: Fostering Improvement Through Innovation I and II

Zenger-Miller Course: FrontLine Leadership

Zenger-Miller Identification Number: 70118FLL

Support Materials: Workbook, video

Short Skill Unit Description:

This unit shows how to tap creativity by drawing ideas from those closest to the work. Participants discuss the role of creativity in problem solving and learn how to encourage risk-taking and how to channel energy into creative approaches.

PONSI Number & Title: 0004. Managing Change and Managerial Problem-Solving

Instructor Type Required:

Average Class Size: 12-16

Number of Students per Year:

Estimated Completion Time: 6 hours

Prerequisite Activities or Instruction: None

Outside Work Required: Time required to implement action plans using new skills

Completion Requirements: Attendance for full class

Prerequisite Work Experience: None required

Prerequisite Formal Education: None required

Standard Texts Available:

SKILL UNIT # 3

Title: Resolving Issues with Others

Zenger-Miller Course: Working

Zenger-Miller Identification Number: 40038W

Support Materials: Workbook, video

Short Skill Unit Description:

In this unit, participants are provided a formula for confronting problems with peers and for generating a mutually acceptable action plan.

PONSI Number & Title: 0011. Interpersonal Skills for the Workplace

Instructor Type Required:

Average Class Size: 12-16

Number of Students per Year:

Estimated Completion Time: 2 hours

Prerequisite Activities or Instruction: None

Outside Work Required: None

Completion Requirements: Completion of assignments and attendance for full class

Prerequisite Work Experience: None required

Prerequisite Formal Education: None required

Standard Texts Available:

SKILL UNIT # 4

Title: Clarifying Customer Expectations

Zenger-Miller Course: QUEST

Zenger-Miller Identification Number: 80016Q

Support Materials: Workbook, video

Short Skill Unit Description:

In this unit, managers and employees learn the skill of uncovering a customer's expectation as a preliminary step in the quality improvement process and how to create a partnership with the customer so as to meet customer needs without compromising.

PONSI Number & Title: 0005. Focusing on Quality and the Customer

Instructor Type Required:

Average Class Size: 12-16

Number of Students per Year:

Estimated Completion Time: 2h 30min

Prerequisite Activities or Instruction: None

Outside Work Required: Time required to implement action plans using new skills

Completion Requirements: Completion of assignments and attendance for full class

Prerequisite Work Experience: None required

Prerequisite Formal Education: None required

Standard Texts Available:

SKILL UNIT # 5

Title: Leading Problem Solving Sessions

Zenger-Miller Course: FrontLine Leadership

Zenger-Miller Identification Number: 70055FLL

Support Materials: Workbook, video

Short Skill Unit Description:

Given the need to balance the process and the content of a problem-solving session, this unit shows how to lead a successful problem-solving session by contributing ideas and encouraging others to contribute theirs.

PONSI Number & Title: 0004. Managing Change and Managerial Problem-Solving

Instructor Type Required:

Average Class Size: 9-15

Number of Students per Year:

Estimated Completion Time: 4 hours

Prerequisite Activities or Instruction: None

Outside Work Required: Time required to implement action plans using new skills

Completion Requirements: Attend all class hours

Prerequisite Work Experience: Leader of a team or group

Prerequisite Formal Education: None required

Standard Texts Available:

SUMMARY SHEET – KNOWLEDGE RETRIEVAL

1. Getting Started

2. The Purpose of Knowledge Selection

3. Explanation of the Activity

4. Review the Knowledge Structure

5. Review the SkillSet Application

6. Explanation of the Task

7. Performing the Task

8. Knowledge Selection Questionnaire

9. Conclusion

TRAINING GUIDE - KNOWLEDGE RETRIEVAL

1. Preparation

Copy the initial database for the extracting experiment from disk to computer.

Start up FoxPro and the SkillSet application.

2. Introduction

Welcome the participant back to the study.

3. Review Activity Purpose

We now move on to the next aspect of the new knowledge organization method. This time, we're using the knowledge structure and the SkillSet Application to find information on the skill units. Again, the purpose of this study is to see whether people in the workplace find this new method useful and effective.

4. Explain the Activity Itself

You will be given a small set of business problems, each of which require the application of a training effort. For each of the criteria, you will use the SkillSet application to find those skill units which address the training needs specified by the cases. You will be observed as to what you do and how you use the application and will be asked after you are done how you feel about this way of using the knowledge organization method.

5. Review the Knowledge Structure

Let's briefly review the knowledge structure. The three dimensions are:

- **Content** - this is a broad description of the discipline into which the multimedia fits. It has three levels: area, subject, and discipline. These are described in some more detail on the help-sheet.
- **Purpose** - these are broad five purposes for which Zenger-Miller develops training materials. Any training material will fit into at least one of these five.
- **Audience** - this describes who the training materials are intended for. For example, materials developed for people involved in teamwork are not always appropriate to, say, corporate executives.

Is this method clear to you? Do you have any questions at this time?

6. Review the Application

Let me show you how to use the SkillSet application for your task. From the main menu, it has the following options:

- Search for a single skill unit using the knowledge-structure search.
- View, edit, and select the skill unit that was entered.

Is this application clear to you? Do you have any questions at this time?

7. Explain the Task in More Detail

Here is what you'll do. You will be given four short descriptions of a business problem which can be addressed by a training program. It is up to you to determine which skill units would best fit the training need, using the knowledge organization method and the SkillSet application.

When searching the available skill units, you may use the reporting option to print out any information you find useful. You can print out information on the skill units you select for the training program using the selection list option.

Please remember that there is no right or wrong way. Please address the business problem in the way you think is best.

If at any point you have a question, please feel free to ask.

8. Provide the Task & Observe

Note the participant's actions on the log-sheets. Being there to answer questions provides a good excuse to remain in the room with the subject and observe him or her.

9. Questionnaire

Thank you for doing this. You did a great job. Now please fill out this questionnaire on which you rate your opinions about what you have just done.

After filling out the questionnaire, do you have anything to add on what you think of this organization method for skill units?

10. Conclusion

Thank you so much for participating in this study. It was very kind of you to free some time to do this. I will be writing up the results in the next few weeks and will send Zenger-Miller, Inc. a summary of my results. Would you like me to send you a copy as well?

12. End Session

Gather participant's training sequences.

BUSINESS PROBLEM 1

The executives of FoodCo, a nationally known food distributor, have recently agreed on the need to implement a renewed focus on quality in their organization. They are currently examining work processes for possible quality improvements and investigating the formation of quality circles made up of employees working in closely related departments. The executives realize that in order for this quality effort to succeed, they will need the commitment and participation of the organization's managers, not all of whom are convinced that the quality focus is a viable activity.

The executives have decided to allow the organization's managers to participate in several training seminars, provided that these seminars take no longer than three days. Using the SkillSet application, which specific skill units would you choose to recommend for this purpose?

BUSINESS PROBLEM 2

The management at SoftWear, a company which specializes in software to support the garment and fashion industries, is worried about the interaction among some of its employees. New product development requires that representatives from marketing, software engineering, interface design, financial planning, and documentation design cooperate closely in order to produce a high-quality product. However, meetings of several new product development groups have resulted in heated arguments with group members accusing each other of not understanding or even disrespecting each other's functions. As a result, product development has slowed down and has sometimes resulted in substandard products, with the different departments blaming each other.

SoftWear's Human Resources Development manager believes that the work-groups suffer from poor communication skills rather than from lack of ability. She is feels this situation could be resolved through training seminars. Using the SkillSet application, which specific skill units would you choose to recommend for this purpose?

BUSINESS PROBLEM 3

AnywAir, a regional airline company operating in the northwest, is rapidly establishing a name for itself with its popular CityHopper service. However, the rapid increase in the number of passengers it serves is straining the company's workforce. As the organization grows, many of AnywAir's employees are encountering new problems on an almost daily basis. Rather than apply their own expertise and experience to solve these problems, the employees frequently relay the problems to their managers. This has resulted in managers spending most of their time on dealing with day-to-day, operational issues rather than with their managerial-level duties. The managers believe that their employees have the ability to solve most of the problems themselves and wish the employees would do so.

To help AnywAir's employees grow with the company, the management feels it would be useful to provide the employees with some training which would teach them how to adapt to their changing work environment and how to deal with new problems. Using the SkillSet application, which specific skill units would you choose to recommend for this purpose?

BUSINESS PROBLEM 4

The relationship between the management and the employees at Buoys-R-Us, a manufacturer of nautical equipment located on the east coast, have slowly, but steadily, deteriorated in recent years. The employees complain that the company's management does not allow them the discretion to do their jobs well and is constantly interfering in operational tasks. The managers argue that most employees require constant supervision so that the work is done well and on schedule. The company's executives believe that this unpleasant work environment has already caused the company to lose several highly qualified managers and employees and would like to turn the situation around. They believe that both the managers and the employees of the troubled departments would benefit from training.

Using the SkillSet application, which specific skill units would you choose to recommend for the managers? Which specific skill units would you choose to recommend for the employees? Are there skill units which the managers and employees can attend and learn from together?

VITA

Paul J.A. van Vliet

Candidate for the Degree of

Doctor of Philosophy

Dissertation: THE MANAGEMENT AND ORGANIZATION OF KNOWLEDGE: A THEORY AND PROTOTYPE IMPLEMENTATION

Major Field: Business Administration

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Personal Data: Born in Leiden, The Netherlands, on May 12, 1964, the son of J.J. van Vliet and J.M.P. van Vliet-van Bezu.

Education: Received Bachelor Degree in Business Informatics from the Gelders Instituut voor H.E.A.O., Arnhem, The Netherlands, in June 1987. Received Master's Degree in Business Administration from Moorhead State University, Moorhead, Minnesota, in May 1990. Completed the requirements for the Doctor of Philosophy degree with a major in Management Information Systems at Oklahoma State University in December 1994.

Work History: Employed as Assistant Data Manager; KLM - Royal Dutch Airlines, Data Information Management Department, August 1986 to April 1987. Employed as Graduate Research / Teaching Assistant; Moorhead State University, Department of Business Administration, March 1988 to May 1990. Employed as Graduate Research Assistant, Oklahoma State University, Central Mailing Services Department, January 1991 to August 1991. Employed as Graduate Teaching Associate / Research Assistant, Oklahoma State University, Department of Management, August 1991 to December 1994.

Professional Memberships: Association for Computing Machinery, Decision Sciences Institute, Institute for Operations Research and the Management Sciences

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 07-26-94 **IRB#:** BU-95-003

Proposal Title: THE MANAGEMENT AND ORGANIZATION OF KNOWLEDGE: A THEORY AND PROTOTYPE IMPLEMENTATION

Principal Investigator(s): Meg Kletke, Paul van Vliet

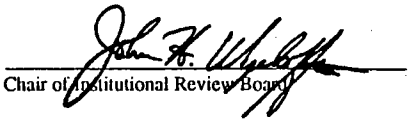
Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

The subjects should also be informed that they may discontinue participation in the study at any time without penalty.

Signature:  Date: July 27, 1994

Chair of Institutional Review Board