Conceptual Models for Knowledge Management:
   An Empirical Study Using Knowledge Forum

by

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Advances in telecommunications and computer software and hardware have led to an
ever-increasing amount of information, and a corresponding need for knowledge
management tools. Knowledge Forum is software designed to support creative work with
ideas, and a goal of its workplace applications is to maximize affordances for knowledge
management while supporting knowledge building and innovation. Recently, conceptual
models have been proposed as supports for knowledge management. Specifically,
models can be used as tools for organizing, representing and communicating information.
The present study sought to empirically evaluate the potential benefits of using
conceptual models as tools for knowledge building in a work environment supported by
Knowledge Forum. A qualitative case study was conducted using six participants.
Conceptual modeling was used first as a tool for each individual to express his/her
understanding of the project and second as a collaborative representation of the groups
understanding.
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1 Introduction

In the past, factors such as capital, productivity and efficiency have been cited as crucial to maintaining the competitive edge of organizations. However, more recently a new perspective has emerged on what elements are important in a successful corporation. Knowledge has become the primary resource for individuals and the economy (Denton 1998). Companies are now forced to achieve a balance between exploration and development of new ideas, and exploitation and refinement of established practices (March 1999). Organizations are challenged to create an environment where innovation is encouraged and maintained, while simultaneously ensuring continued productivity and efficiency.

The most crucial component of growth in an organization is innovation. Organizations strive to continuously deliver innovative new products and services at an ever-increasing rate. As a result, companies are being forced to take a systematic and deliberate approach to managing the forces driving innovation, namely the productivity of the knowledge worker and the fast and efficient creation and use of the collective knowledge of an organization (Borghoff 1998). Efforts to meet this challenge have been focused within the field of knowledge management.
Traditionally, knowledge management has centered on dealing with the ever-increasing amount of information available to workers by producing technological solutions that assist workers in molding their information into organized, grouped and categorized data sets, thereby boosting worker productivity. Essentially, knowledge management has become a synonym for information management, blurring the vital distinction between information and knowledge. Information is a set of data, organized into patterns to create meaning. Knowledge is information put to productive use, enabling correct action (Borghoff 1998). Knowledge is not equivalent to information and therefore information management is qualitatively different from knowledge management. The biggest barrier to a successful knowledge initiative has been this lack of differentiation between knowledge and information. Companies invest in what they call knowledge management, but instead wind up managing their information, improving their productivity, but not addressing the crucial task of converting information into knowledge. Knowledge management literature repeatedly stresses that organizations that innovate grow. Innovation is enabled through knowledge; therefore the key to organizational growth is knowledge creation.

Information is converted to knowledge through human processes of shared understanding and sense-making at both the individual and collective level. In order to support knowledge creation, knowledge management must focus on the importance of people and
their work culture and practices. While previous work in information management focused on technology and information access, knowledge creation is centered around creating and supporting a knowledge building environment where individuals work together to create, refine and elaborate knowledge.

Effective collaboration and communication are crucial to effective knowledge building. However, as technology changes and advances, it has become a challenge for organizations to support collaboration and communication between workers (Fischer 2001). Individuals are finding it more and more difficult to manage and utilize the growing amount of information available to them. It is up to scientists to develop theories, tools and techniques to manage information and promote effective communication of ideas and group collaboration. One potential tool to facilitate organization, representation and communication of ideas is the use of conceptual models.

Conceptual models are symbol-structures intended to capture the meaning of information and organize it to make it understandable and useful to people. Models have been used primarily as tools in object-oriented development to represent and organize the relevant concepts in a given application-domain. Rumbaugh (1991) states that the greatest benefit of conceptual modeling is in helping specifiers, developers and customers clearly define abstract concepts and effectively communicate them to each other. Based on their use in
object-oriented development, conceptual models have been postulated as valuable tools for knowledge management, specifically for representation and communication of information. However, while conceptual models are hypothesized to play a vital role in representing concepts and facilitating collaboration during the development stage of information system design, models have never been studied independently as tools for knowledge management. This study used conceptual models as tools for organizing, representing and communicating knowledge in an open, collaborative work environment and sought to identify important factors that may mitigate their efficacy.

Many researchers have argued that inventing knowledge cannot be viewed as a specialized activity, instead it must become a way of behaving in which everyone is a knowledge worker within a community (Senge 1990; Nonaka 1991). Knowledge creation cannot be confined within and between organizations, there is also a wider social context. The culture and accepted practice of our society is changing in response to new knowledge media. Not only organizations, but entire communities are moving towards a knowledge society where individuals are challenged to work at the edges of their competence (Scardamalia 2000) , together contributing ideas to a community where knowledge is shared, refined and elaborated. Knowledge building then becomes a pervasive activity. Scardamalia writes that the advancement of a knowledge society requires systems to be developed that "enable rather than presume advanced knowledge
processes" (Scardamalia 2000). Knowledge Forum® has been designed to act as precisely such a tool.

Knowledge Forum is a database application that can serve as a collaborative tool for knowledge management and knowledge building in schools, communities and organizations. Using Knowledge Forum, individuals work together to create a database composed of notes. A note is a text or graphics based representation of an individual's own learning and theorizing. All notes posted in the database are available to anybody within the community. Notes may include a statement of the problem and an action plan, as well as a summary of relevant events and resources for a given project. Individuals also contribute notes expressing divergent ideas or theories, resulting in an ongoing dialogue between team members. As a result, Knowledge Forum is not simply a source of static information, instead it is a dynamic, constantly evolving meeting place where individuals can collaboratively build and refine a communal body of knowledge.

To date, knowledge management has been focused on worker productivity and streamlining business processes to reduce costs (Borghoff 1998). As companies shift their attention to growth, enabling innovation through knowledge creation has become a priority. Effective use of information technology to support knowledge creation within organizations is an ongoing challenge. There is a constant need to improve and refine
existing tools and technologies to more effectively support knowledge building.

Knowledge Forum is explicitly designed to act as an environment that enables knowledge creation and innovation. Conceptual models have been used as effective tools for organizing and representing information in the context of requirements engineering.

Using both Knowledge Forum and conceptual models as tools, this study sought to investigate the use of conceptual modeling within the Knowledge Forum environment as a tool for organizing, representing and communicating knowledge in a workplace setting.

The motivation for the study was twofold; first to investigate the use of modeling as a support for knowledge building in an organizational context and second to determine if the use of conceptual models within Knowledge Forum could strengthen both conceptual models and Knowledge Forum as knowledge creation tools.

The study was conducted with a six-member team using Knowledge Forum as their primary workspace. Individuals were first asked to use modeling as a tool to express their understanding of their project. Subsequently, the entire team was asked to collaborate and construct a group model of the goals, subgoals, events and actors involved in the project. This group model was placed within the Knowledge Forum environment and participants were asked to work using the model as a guideline. The results were divided into three areas; 1) issues surrounding the task of creating the model were investigated, 2) the efficacy of modeling as a tool for organization, representation
and communication of knowledge was evaluated, and finally, 3) the use of Knowledge Forum in conjunction with a shared conceptual model was examined.

2 Conceptual Models

2.1 A Brief Description

In order to be used, information must be represented in a way that captures its meaning and inherent structure. Conceptual models are computer-based symbol-structures intended to meet this representation challenge. Models use semantic terms such as goal, actor and event to model a given application domain. Furthermore, models make ontological assumptions that determine what components are built into the model and therefore define its range of applicability (Mylopoulos 1998). Essentially, each model has a particular ontology that delineates what is relevant in the application domain. This acts as an abstraction mechanism, filtering out all extraneous information from the model.

There are a number of theoretical and practical rationales for why conceptual models may serve as effective tools for organizing, representing and communicating ideas within organizations.
2.2 Mental Models and Shared Mental Models

2.2.1 Mental Model Theory

Mental model theory attempts to explain higher cognitive processes by postulating the existence of mental models in the place of other forms of semantic representation (Johnson-Laird 1983). The theory argues that by replacing the formal rules of a hypothetical mental logic with mental models, it is possible to give a better explanation of processes such as meaning, comprehension, inference and discourse (Johnson-Laird 1983). Mental models have been described as the semi-permanent tacit maps of the world stored in long term memory, and also as the short term perceptions which people accumulate as part of their everyday reasoning processes (Senge 1994).

A mental model is viewed as an organized knowledge structure that can include objects, situations, events and the relationships between them (Cannon-Bowers 1993). These structures allow individuals to represent objects, situations, sequences of events and the real world. In addition, they enable people to make inferences, understand phenomena, make predictions, decide on a course of action and control its execution.

Mental model theory argues that inference is not made by recourse to mental logic (Johnson-Laird 1993). Instead, people reason by constructing a representation of the
events described by the premises of a given argument. The representation is based both on the interpreted meanings of the premises and also on implicit inferences that come from general knowledge and past experience. On the basis of the initial model, individuals draw conclusions and evaluate them. Mental models are not fixed structures in the mind. Instead they develop over time, incorporating both information from past experiences and new interactions with the world. As new information is gathered, incomplete models are elaborated and inaccurate models are corrected or dismissed (Gentner 1983).

Models are not objective representations of the real world. Instead they are subjective abstractions that serve to emphasize information relevant to the individual while ignoring any data deemed irrelevant. As a result, mental models are generally simpler than the entities they represent. Humans are parsimonious in their construction of models, preferring to keep mental complexity to a minimum (Gentner 1983).

The theory of mental models provides a basic theory for understanding how people think about the world. According to Senge, (Senge 1994) the extent to which the mental models of workers within an organization overlap will have a significant impact on that organization's ability effectively communicate and collaborate. In particular, in situations involving interdisciplinary teams dealing with complex and ill-defined problems, there
may be significant benefit to externalizing each team members mental models (Kearney 1997). Conceptual models can act as a potential tool to explicitly represent individual mental models, facilitating the communication and exchange of ideas. The clear parallels between the structure of mental models and conceptual models support the idea of using conceptual models in this context.

2.2.2 Shared Mental Models

Coordination is the necessary extra effort teams must provide to achieve collaborative goals. Techniques to facilitate coordination include, division of labour, and effective communication. More recently the concept of a shared mental model has emerged. Shared mental models are dynamic representations of some dynamic process or system. While mental model theory attempts to define individual cognitive processing, the theory of shared mental models is concerned with group processes. A shared mental model can be described as a 'knowledge structure held by members of a team that enable them to form accurate explanations and expectations about the task and to coordinate their actions and adapt their behaviours to the demands of the task and other team members.' (Cannon-Bowers 1993).

It has been widely argued that team performance is improved when the team holds a shared mental model. Models improve coordination by substituting for direct
communication, allowing effective task assignment and providing common ground for more efficient communication, thereby improving project planning and execution (Rasker 2000; Russell 2000). Shared models provide teams with a common problem space, resulting in the improved ability of team members to predict the information needs and behaviours of other team members and act accordingly to maximize performance.

Factors that contribute to the development of a shared mental model include; teams that have worked together previously, good communication and effective division of labour (Russell 2000). By allowing team members to co-construct an explicit artifact of their knowledge, conceptual models can potentially serve as tools to facilitate the development of a shared mental model. In fact researchers have argued that a shared conceptual model can lead to the development of a shared mental model (van Engers 2001) and therefore can be an important tool in fostering effective teamwork.

2.3 New Theories of Knowledge and the Mind

There is a new conception of mind that has been taking shape in cognitive science over the past decade. Traditional theories treat knowledge as objects that exist in the mind, Mental model theory and shared mental models are consistent with this conception of knowledge. However, in the information age we face new challenges that cannot be
easily incorporated into our prevailing theory of mind and force us to reconsider long
held assumptions (Bereiter in press) The basic conception of the mind as a container of
objects which are worked on during cognition, cannot be reconciled with terms such as
knowledge building and knowledge society, ideas that demand that knowledge exist and
be manipulated within communities. Instead, new theories are being advanced, including
situated cognition, constructivism, social constructivism, and connectionism.

While conceptual models fit nicely into the prevailing theory of mind supported by
mental model theory, they are also compatible with theories that do not define knowledge
in the same way. Conceptual models are explicit representations of individual or group
ideas and understanding. As such, they may externalize knowledge in the mind, or they
may represent knowledge that exists within the collective. Modeling can act as an
effective tool within either theoretical framework.

2.4 The Knowledge Life Cycle

Knowledge creation is an ongoing process that occurs through exchange, refinement and
describe four phases of knowledge conversion. Their description focuses on the
distinction between tacit and explicit knowledge. Explicit knowledge is formal
knowledge that can exist as information in organizational documents, e.g. reports, manuals, patents etc. and also in representations of the organization itself, e.g. mission statements, domains of expertise etc. (Borghoff 1998). Conversely, tacit knowledge is personal knowledge, created in individuals through learning and experience and shared and exchanged only through personal communication between individuals. Tacit knowledge is easily shared, while explicit knowledge must be acquired, re-coded and internalized as tacit knowledge.

Both tacit and explicit knowledge are equally necessary for any organization to thrive. However, their mere presence is not sufficient. The more difficult and necessary factor in organizational growth is knowledge flow within an organization. If knowledge doesn't flow, it doesn't grow and eventually becomes obsolete.

Knowledge that flows is shared, acquired and exchanged and therefore generates new knowledge. Fig. 1 shows the cycle of knowledge conversion postulated by Nonaka and Takeuchi (1995). Existing tacit knowledge can grow through socialization in communities. New tacit knowledge can be created through learning and training, resulting in internalization of explicit knowledge. New explicit knowledge can be generated through externalization of tacit knowledge. Existing explicit knowledge can be shared, exchanged and elaborated within an organization.
One challenge of knowledge management is the task of creating an environment where knowledge can flow through all the phases of its life-cycle (Borghoff 1998). Much of the environment of an organization is created by its IT structure. So an important question becomes; what IT infrastructure can effectively contribute to the development of an environment that supports knowledge flow? More specifically, what kind of software is necessary to support exchange of tacit knowledge in an organization of knowledge workers? How can the expanding amount of explicit knowledge contained in the documents of an organization be managed through IT?

Nonaka and Takeuchi (1995) discuss the need to convert tacit knowledge to explicit knowledge through socialization of tacit knowledge. Conceptual modeling offers a way to achieve this conversion by acting as an externalization of tacit knowledge and moreover, providing a consistent language for all stakeholders to express their understanding. The model defines what can exist within the modeling framework,
including the types of relationships between entities. This forces all information to be represented in one form, thereby facilitating representation and communication of ideas. Moreover, modeling can be used as a tool to organize existing explicit knowledge, making it more readily usable and coherent to workers.

2.5 Applications of Conceptual Models in Requirements Engineering and Knowledge Management

2.5.1 Requirements Engineering

It is widely accepted that effective communication and collaboration are critical to system development and design (Jirotka 1994; Damian in press). Most of the information necessary for effective requirements engineering is embedded in the social and mental worlds of users and managers. Generally, information must be extracted using interviews and questionnaires. However, information extracted in this manner tends to be informal and subject to variable interpretation (Goguen 1994). Additionally, it is difficult to reconcile conflicting viewpoints and establish communication and collaboration between stakeholders (Damian in press). Using computer-based symbol structures, such as conceptual models allows representation to become more formal, governed by a set of syntactic and semantic rules.
Researchers have identified four 'worlds' that must be understood and modeled during the development stage of information system design (Jarke 1992). The subject world consists of the subject content of the information system. For example, the subject world for a hospital system would consist of patients, doctors, appointments etc. The system world describes the information system itself, incorporating several levels of implementation detail. The usage world describes the setting in which the system is to be implemented and consists of components such as agents, events and projects. Finally, the development world describes how the information system was created, including the teams involved, the methodology and design decisions and rationale. All the information in each world is necessary during the development stage and also later during operation and maintenance. Consequently, there is a need for the information to be represented to create a comprehensive framework for information system design.

Object-oriented Modeling Technique (Rumbaugh 1991) uses models as tools for abstraction; defined as the selective examination of certain parts of a problem. Abstraction represents only the relevant components of a problem based on some stated purpose. It should be noted that generally, abstractions are incomplete and inaccurate, however a good model should capture the crucial components of a problem while eliminating any nonessential elements. Object-oriented Modeling Technique uses three types of models to describe a system; the object model, which describes the objects in a
system and the relationships between them; the dynamic model, which describes the interactions between objects in a system; and the functional model, which describes the data transformations of the system. A complete description of the system requires all three models.

Object-oriented Modeling Technique offers an example of how models have traditionally been used in information system design. The use of models in this context is based upon the assumption that they act both as tools for representation and collaboration. Models are hypothesized to enable the various stakeholders in the design process to effectively communicate abstract and complex concepts. However, to date, systematic empirical study has not been conducted to evaluate this claim.

2.5.2 Knowledge Management

The assertion that conceptual models are beneficial to effective collaboration, communication and representation has more recently led to their use within a different framework. In the past, the use of conceptual models has been primarily limited to the development stage of information system design. Models are now being proposed as a tool for knowledge management. As organizations attempt to optimize their knowledge resources, it is important that knowledge be modeled, structured and interlinked.
Ontologies, and specifically conceptual models, offer a way to formalize the knowledge shared by a group of collaborating workers (Staab 2001).

One example of this use of conceptual models is the EXIP (Executive Information Portal) project (Mylopoulos in press). The goal of the project is to develop a prototype knowledge management system for use by strategic business analysts. Strategic business analysis involves defining company objectives, tracking events and documents both internal and external to the company and assessing the effects on the defined objectives. EXIP provides a conceptual model of strategic business analysis, including strategic objectives, sub-goals and the relationships between them. The system attempts to make use of a conceptual model to help users form more accurate representations of the strategic objectives of the organization and more effectively select and organize relevant information. Additionally, the model provides a uniform platform for framing objectives to help build consensus between analysts. It is hypothesized that the conceptual model will assist strategic business analysts in their individual assessments and also improve collaboration and communication between analysts. However, the use of conceptual models as expressive tools to assist individuals in representing and communicating their understanding has yet to be thoroughly investigated.

A further example of the use of conceptual models as tools for knowledge management is a research program called Power (program for an ontology based working environment
for rules and regulations) (van Engers 2001). The primary function of Power is to translate legislation and regulations into conceptual models. Power operates on the assumption that as experts work together to create and refine conceptual models of their work, they develop a shared mental model. In this manner, knowledge is made explicit, creating a valuable body of knowledge. However, while there has been extensive research linking shared mental models to effective teamwork, (Cannon-Bowers 1993) to date, there has been no empirical evidence linking the use of a shared conceptual model to the development of a shared mental model.

2.6 Concept Maps vs. Conceptual Models

It is useful to differentiate between concept maps and conceptual models. Concept maps are tools for representing and organizing knowledge (Novak 2001). Maps usually consist of nodes and links between them. Nodes represent a particular concept. Concepts are defined as a perceived regularity in events or objects, or records of events or objects, designated by a label. Links identify the relationships between concepts using a proposition specified on the links themselves. Propositions are statements about some
naturally occurring or constructed object or event in the universe.

Fig. 2 Concept Map of Photosynthesis

On first glance concept maps appear to be quite similar to conceptual models, however there are several key differences both in their structure and use. Conceptual models are intended to organize information in a meaningful and useful manner. Specifically, they are used to provide syntactic and semantic consistency in defining abstract concepts. As such, they are well suited to assisting communication between individuals and facilitating collaboration. They accomplish this, however, at the risk of being overly constraining. In contrast, Concept maps lack any fixed, consistent semantic or syntactic structure. This leaves them open to a greater range of semantic and syntactic relationships. It also creates the added complication that the mapper must clearly define the meaning of every link and clearly specify the nature of each concept. There are no boundaries placed on
what can exist in a concept map. Essentially, concept maps lack any pre-defined ontology. As a result, while concept maps may be effective as tools to assess individual understanding of a given subject area, they do not naturally lend themselves to development of a common problem space. Conversely, because conceptual models have a predefined ontology, users must express their understanding using particular elements. This facilitates communication, because all ideas are expressed using the same components. Of course if there are problems with the ontology, this will create serious communication problems. The goal of a knowledge building environment, such as Knowledge Forum, is to accommodate emergent goals and to embed discourse for effective community action into the day-to-day workings of the organization. As indicated below, the predefined ontology for the conceptual modeling framework used in this study was revised slightly for this purpose. The need for revisions to facilitate use in actual communities of practice raises fascinating issues for the future use of conceptual models as supports for knowledge creation within organizations.

Concept maps are often deemed useful based on the implicit assumption that they act as representations of mental models. However, identifying the relationship between mental models and concept maps has proven to be a very difficult task. Part of the difficulty lies in the fact that concept maps are theoretically explicating a phenomenon that is itself only theoretical in nature (Passmore 2001). However, it is undeniable that the structure of concept maps closely mirrors the proposed structure of mental models. Conceptual models are very similar in structure to concept maps, therefore any postulated
relationship between concept maps and mental models would appear to lend credence to the idea that conceptual models can also be analyzed within the framework of mental model theory.

3 Principles of Knowledge Building

There are twelve facets of knowledge creation described by Scardamalia that define the ways in which knowledge work must be extended to create effective knowledge building (Scardamalia 2000). Four of these principles relate more specifically to knowledge building within organizations (Scardamalia 2000) and are further elaborated here;

1. Community Knowledge

Community knowledge refers to the increasing emphasis on collective contributions rather than individual performance in the pursuit of excellence. In a knowledge society, it is important that knowledge be shared and elaborated upon. Community knowledge goes beyond information access; it requires that ideas be shared, acquired and exchanged, generating new knowledge.

2. Rise Above

Rather than working at one level of thought, knowledge building requires that resolving conflicts and solving problems always lead to higher levels of
processing. The result is a more diverse and complex set of ideas that characterize innovative work. Individuals and communities must consistently work at the limits of their abilities, adapting to new ideas by creating emergent goals rather than fixating on some static initial benchmark. Ideas must be translated into action, leading to new contexts and new problems.

3. **Improvable Ideas**

Throughout the history of science, accepted theories have been improved upon, revised or replaced. The pursuit of new knowledge and new ideas and the commitment to improve on accepted existing theories have characterized expert knowledge creation for centuries. It follows therefore, that commitment to continually build more complete knowledge at both the individual and collective level is an important part of effective knowledge building.

4. **Symmetric knowledge advancement**

Knowledge building is advanced when knowledge flows within and across communities engaged in knowledge work, creating a synergistic relationship between them. This is in contrast to the common practice of having multiple individuals in an organization engaged in the same activity, not learning from one another. Or in schools, where the teacher's knowledge often does not advance as she instructs her classroom. Knowledge resources are maximized when communities share knowledge and learn from each other and the leader or
manager is also learning in the process, creating a collective knowledge building environment.

4 Knowledge Forum™

4.1 The Knowledge Forum Client

Knowledge Forum is designed specifically to enable and support the core facets of knowledge creation described above through a number of software features. Supports in Knowledge Forum include; multiple formats for representing knowledge such as text and graphics, the ability to establish connections between notes and the ability to have notes refer to other notes within the database. Additionally, notes can be updated by their authors and annotated by other community members. Knowledge Forum notes also include customizable scaffolds intended to support high level processes by reminding and encouraging certain types of analysis of information. By using these supports, individuals are able to represent the growth and change of their knowledge.

Another feature of Knowledge Forum important to knowledge construction is the ability to create "views". These are essentially a visual means to organize thinking through the placement of notes in a shared environment. A single note can appear in more than one view, allowing concepts contained in a note to be framed in a variety of ways.
There are several tools within Knowledge Forum designed to support effective community knowledge creation. Perhaps the most powerful collaborative feature in Knowledge Forum is the public nature of the database. Because of this feature, interaction in Knowledge Forum is different from traditional discourse settings, allowing all members of the organizational community to both observe and participate in all exchanges that take place within the database. In contrast to meetings and training sessions which involve transitory, face to face discourse, computer mediated communication through Knowledge Forum preserves knowledge, allowing users to return to their ideas, and the ideas of others as needed.

Aside from the public nature of the database, Knowledge Forum uses additional supports to facilitate collective knowledge building. Example most relevant to this study include:

1. **Build-on** allows individuals to build on the ideas of others. A build-on is a note itself, connected to the initial note by a visible link. Build-on notes can also have additional build on notes attached to them. Users have the ability to add a note of their own, at any place in the build-on structure. This feature allows enables connections between notes and facilitates the organization of the knowledge in a view. It also allows newcomers to the view to clearly follow the thread of an ongoing discussion.
2. **Quote** enables users to reference someone else's work. A quote creates a direct link to the quoted material and a reference is added to the notes.

3. **Collection** allows users to collect a series of notes from anywhere in the database relating to a common topic or idea. Knowledge is then organized for ongoing discussion.

4. The **shared authorship** capability of Knowledge Forum allows notes to be co-authored by a number of users at different points in time. Users that are designated as "authors" of a shared note are able to edit the note.

5. **Add-to** enables users to place an "add-to" box in a note to solicit contributions from other users. This is particularly useful when users wish to collaboratively construct an idea.

6. **Rise-above** allows users to create a rise-above folder gathering theories and ideas that have been presented and "rising-above" these ideas to new levels of understanding. Notes contained within a "rise-above folder disappear visually from the view and are accessible only through the "rise above" note.

7. Customizable **scaffolds** allow managers and users to co-construct a language useful in their day-to-day work. Users and managers use their set of scaffolds to frame the information contained in their notes and define what is most relevant to the group.
<table>
<thead>
<tr>
<th>Core Facets of Knowledge Creation</th>
<th>Technology Innovation:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Community Knowledge</strong></td>
<td><strong>Knowledge Forum®</strong></td>
</tr>
<tr>
<td>Contribute to collective knowledge advancement and shared goals; contribute ideas to communal design spaces; serve as a valuable team member; cultivate openness in knowledge work</td>
<td>Bolded items refer to processes specifically supported by Knowledge Forum software</td>
</tr>
<tr>
<td><strong>Rise Above</strong></td>
<td></td>
</tr>
<tr>
<td>Move to increasingly higher levels to resolve conflicts and to solve problems; transcend expectations; accommodate complexity, diversity, and messiness; translate ideas into action and new contexts; engage in progressive problem solving and self assessment</td>
<td><strong>Rise-above notes</strong> and <strong>views-of-views</strong> support increasingly high-level formulations of problems and ideas, as well as <strong>coherence</strong> and <strong>synthesis</strong> of ideas; the rise-above-it principle is reflected in <strong>publication-and-review</strong>, in a multimedia journal, in individual and group <strong>portfolios</strong> and in multiple representations of ideas, viewed from different perspectives; customizable <strong>scaffolds</strong> for high-level knowledge processes support <strong>theory refinement</strong>, evaluation of evidence and counterarguments, <strong>constructive criticism</strong>, <strong>experimentation</strong>, and a host of high-level knowledge processes.</td>
</tr>
<tr>
<td><strong>Improvable Ideas</strong></td>
<td></td>
</tr>
<tr>
<td>Cultivate promising and improvable ideas; sustain inquiry at the edges of understanding; move beyond current best practices; work with emergent goals; approach problems as opportunities</td>
<td><strong>Idea improvement</strong> is supported through <strong>peer review</strong>, <strong>coauthored</strong> notes and views, links to views of different team members, higher-order <strong>conceptual frameworks</strong>, <strong>reorganization</strong> and revision, and integration of <strong>new information</strong>; <strong>process models</strong> and <strong>knowledge-building discourse</strong> are supported through <strong>animation</strong> and <strong>video notes</strong></td>
</tr>
<tr>
<td><strong>Symmetric knowledge advancement</strong></td>
<td><strong>Analytic tools</strong> work in the background and record processes automatically--research and reflection become integral to the workings of the organization; participants serve as ethnographers of knowledge building.</td>
</tr>
<tr>
<td>Progressive refinement of ideas within and between communities; work at the cutting edge of inquiry; situate and refine ideas in the context of broadly distributed communities</td>
<td><strong>Interleaved local-and wide-area networks</strong> support the work of local and globally configured communities; <strong>replication, merger</strong> of workspaces, and a system of <strong>virtual visitations</strong>, support <strong>knowledge building discourse</strong> within and across communities; <strong>online-offline synchronization</strong>, wireless capabilities, and <strong>Palm KNOWLEDGE FORUM</strong> will soon provide <strong>anytime, anywhere access</strong></td>
</tr>
</tbody>
</table>

Fig.3 Supports for knowledge creation in Knowledge Forum (Scardamalia 2000)
4.2 Analytic Toolkit (ATK)

The Analytic Toolkit is a program designed to provide summary statistics on activity in a Knowledge Forum database. ATK measures include, how many notes there are in the database or in a particular view, how many notes a user has created, which views a user is working in, what percentage of the notes a user has read, use of build-ons, keywords, references and other knowledge building features and who has read and written new notes during a particular time period. It is intended to be used by database managers, researchers, and participants in the database.

There are different types of database analysis that the ATK can perform. These include;

1) Basic Knowledge Building Measures. This profile is used to assess a user's contributions to the database from a knowledge building perspective. The analysis is intended to address the following issues; is the user collaborating with other users, or working alone? Is the user reading and contributing to other work in the database? Does a user's work encompass a variety of different views and problems, or is it concentrated in one area? The measures are; number of notes contributed, percentage of notes that are linked to other notes, percentage of notes that have been keyworded, number of views worked in, number of problems worked on, percentage of notes in the database that the user has read, and the number of times the user has revised a note.
2) **Use of Features.** This measure is intended to assess whether users are using the knowledge-building features that are available in Knowledge Forum. Questions that can be investigated include: when new features of Knowledge Forum are introduced to a group, which users are making use of them? Is the use of these features correlated with advances in knowledge? The measures used in this analysis are: number of user's notes that are part of a build-on tree, number of keywords used, number of references in the user's notes, number of rise-above-it notes, number of views created by the user, number of scaffold supports used and the number of annotations that a user has made is shown.

3) **Use of scaffold supports.** This report gives a detailed breakdown of which scaffolds and supports each user has used. Are new scaffolds being used?

Other forms of analysis in ATK include single user reports, activity logs for single or multiple users, tracking specific activities such as note reading and note creation and identifying which users are interacting.
5 Present Investigation

Conceptual models have been used as tools for representing and organizing ideas, primarily in a requirements engineering context and more recently in some knowledge management software. The first stage of this study used conceptual models as tools for individuals to organize and represent their knowledge and attempted to identify issues that affect the efficacy of modeling as a tool for knowledge management and knowledge creation.

Knowledge Forum offers a unique open collaborative work environment that supports the principles of knowledge building necessary for effective knowledge creation. It was hypothesized that incorporating a conceptual model within the Knowledge Forum environment could be a valuable addition to the knowledge building supports already existing in Knowledge Forum. In the second stage of this study, participants were asked to collaborate and create a collective conceptual model of their project. This collaborative model was then placed into the Knowledge Forum environment, intended as an additional tool to help participants collectively organize, refine and elaborate their knowledge.
The results were divided into three areas 1) the task of creating the models was evaluated 2) the usefulness of the models as tools for representation, organization and communication was evaluated 3) the use of the collaborative model within Knowledge Forum was evaluated.

5.1 The Setting

The investigation was conducted using KBShare, the Knowledge Forum database used to support the work of the Knowledge Forum Lab at OISE/UT. KBShare consists of a number of views where authors contribute notes related to a particular topic. Fig. 4 shows the welcome view where all users enter KBShare. The main links on the left represent views for key workspaces. Users can go to any view by clicking on one of the links.
In addition to views on a particular subject, there are team views used as work environments for small teams working on a particular project. For example, Fig. 5 shows
the view devoted to work on the development of a math editor for Knowledge Forum.

![Image of a math editor development view](image.png)

**Fig. 5** The view for the team collaborating on the development of a math editor

For this project, the database project team was used. The team consisted of six people and used the database project view as their primary workspace. The database project represented an ill-defined task. Participants had a general framework for their work (see Fig. 6), but the project was expected to grow as each team member contributed ideas from their own particular area of expertise.
The purpose of the database project was to plan and construct a research databank. Prior to the beginning of the project there were three planned initiatives. First; the design and creation of the databank, second; the production of results based on the databank and third; the development of a sophisticated testing program, tuned to the needs and accomplishments of particular research sites. At the time of this study the team was in the first stage of the project. Fig. 6 shows the first note contributed to the view stating the purpose of the project.

Fig. 6 Purpose of the database project
5.2 The Conceptual Model

The conceptual model used in this study was borrowed from the EXIP project (Mylopoulos in press). The model provides a description of a project in terms of a network of relationships between goals, soft-goals actors, events and documents. A goal is defined as a desirable state of affairs. Goals can be decomposed into sub-goals through two types of relationships:

1. The AND-relationship relates a goal to a set of sub-goals such that fulfilling all sub-goals is a sufficient condition for the fulfillment of the goal.

2. The OR-relationship relates a goal to a set of sub-goals such that fulfilling at least one of the sub-goals is a sufficient condition for the fulfillment of the goal.

In many instances, lateral influences may also exist between two goals. Such influences are represented in terms of effect relationships, which can be labeled “+” or “-“, depending on the nature of the influence.

For the purposes of this study, soft-goals were added to the EXIP modeling framework.

Soft-goals are defined as goals that lack a clear definition and therefore do not have
clearly defined criterion for fulfillment. Conversely goals have formal definitions and can be easily identified as satisfied or unsatisfied.

An additional concept in the EXIP semantic model is an event. Events are related to goals in several different ways. An event is an occurrence of an activity. Events may cause the fulfillment of a goal, or contribute to the fulfillment of a goal positively or negatively. Events may also serve as indicators of the progress of a particular goal. In addition to specific events, the model also includes event instances; types of events that may be relevant to each goal and how they may effect it. Event instances allow the user to focus on potential relevant events and predict their effects.

In order to more clearly delineate the relationship between goals and events, Fig.7 below shows an example of a goal decomposition within the EXIP modeling framework. It is important to note that the structure of the model is a hierarchy of goals and events. The square boxes represent events while goals are oval. The key point is that all goal decompositions result in event(s) or event-type(s). Users are expected to
Fig. 7 Sample model for the goal "become a leading media broker/distributor".

effort goals by refining them through sub-goals and finally translating them into a concrete context by identifying an event or event type relevant to either the fulfillment or elimination of the goal.
Apart from goals and events, the modeling framework also includes the concept of an actor. An actor is an organizational unit. Actors can be associated with goals in two ways. Through a dependency relationship, where satisfying a goal depends on a particular actor, or through an interest relationship, where satisfaction of a goal especially concerns a specific actor.

The final component of the model is a document. Documents can be viewed as supporting or refuting evidence for a particular goal, event or link. Documents may be classified within three separate taxonomies. For example, a particular paper or URL is first classified in the goals taxonomy to see if it is relevant to any goals. Then, it is classified within the events taxonomy to evaluate if it belongs to any relevant event nodes in the model. Finally it is classified within the links taxonomy to examine if it is relevant to a link between any two concepts in the model. For example a document may affect the link between an event and a goal. For the purpose of this study, participants were told that notes within the KBShare database could be classified as documents.
5.3 Method

5.3.1 Participants

The participants in the study were the six members of the database project team. This team used the database project view within KBShare as their primary work environment. The database project was only one part of each member's workload and the contributions of each member were variable depending on other projects and commitments.

5.3.2 Procedure

Participants each received either an individual or small group tutorial on how to construct a conceptual model using the components from the EXIP model. Participants were given instructions in written form (see appendix) to take with them and asked to individually construct a model of their understanding of the Database Project using only the components of the model they had been given. Participants were told they had the option of sending the principal investigator of this research study several drafts of their model for feedback if they encountered difficulty. Each participant was given at least 10 days to complete the model. Participants were instructed to only contact the principal investigator for assistance and to not discuss their models between themselves.
After all the individual models had been collected a two-hour meeting was scheduled with all six participants and the principal investigator. At the beginning of the meeting participants were asked to complete a questionnaire (see appendix) to evaluate their thoughts on the modeling task they had just completed. Each question had a scale from one to five, where 1 was 'not at all' and 5 was 'very well'. In addition to the scale, participants were asked to explain each answer.

Following the completion of the questionnaire, through discussion and negotiation, participants collaboratively constructed a model that they felt best represented their group objectives up to the time of the meeting. Modeling software and a digital projector were used to facilitate the task.

Following the meeting the collaborative model was placed in the background of the database project view in KBShare. Participants were asked to use scaffold supports to incorporate all new notes contributed to the view into the collaborative models. The five scaffolds were intended to mirror the structure of the model itself. Goals and subgoals were represented by the "new goal" and "existing goal(s) this note relates to" scaffolds. Participants were asked to use the "positive interaction" and "negative interaction" scaffold to indicate positive or negative lateral relations between notes. The "what we're doing" scaffold was intended to help participants link a particular event or activity to the
goal(s) stated in the note. Fig. 8 shows the note placed in the view explaining this procedure to participants.

Fig. 8 The note instructing participants on the use of scaffolds relating to the model
After the model had been in place within the view for approximately 7 weeks, participants were asked to participate in an open-ended interview (see appendix) to discuss their experiences using conceptual models.

The Knowledge Forum Analytic Toolkit (ATK) was used to compare each participant's activity within the rest of the KBShare database to their contributions within the database project view during the study period. The ATK was also used within the database project view to investigate activity within the view prior to the introduction of the collaborative model and after the model was in place.

6 Results

The study took place over the course of a two and a half-month period. During this time, participants did not spend extensive time working on the database project. Work time varied from a total of 6 hours to 4 days in the entire two-month period. All participants agreed that this was less time than they had been spending on average before the study began. A number of factors were identified that contributed to the decrease in work, including; family crisis, new funding concerns, and higher priority projects.
Participants were asked, "At the beginning of the conceptual model study, how did you believe that using conceptual models would affect the project?" Generally, participants were cautiously optimistic about the potential benefits of using conceptual models. Comments included the possibility that models would "improve the communications between the different members and increase understanding of what was going on", that "making goals of the project clear to the people working on it might give it more direction" and that "it might help me move forward with what I was supposed to be doing".

6.1 Task completion

Individual Models

- Five out of six participants completed the individual model. One participant declined due to inability to formulate goals for the project.

Questionnaire

- All participants completed the questionnaire.

Group Model

- All participants participated in the creation of the group model.

Interview

- Five out of six participants were interviewed.
6.2 Evaluating the task of creating models

6.2.1 Individual model construction

Participants were asked to complete their models within approximately 10 days. The
construction was estimated to be a 3-hour task and was to be done during working hours.
One month was required for all models to be collected. This result was surprising
because the task had been initially estimated to take a most half a day. During the
interviews, when participants were asked "what was the most negative aspect of using or
contemplating the use of semantic models for this project?", two participants mentioned
the issue of time, pointing out that the model was time consuming and that the time used
for creating the model could have been used doing another task. A third participant
commented that it "might have been better just to work in the view than to do that".
However, one participant stated that "the creation of models like this is thinking time,
where you refine and elaborate thoughts. If I wasn't doing that, then I would not have
completed the thinking about it or I would have done it another way". Despite one
opinion to the contrary, it was generally apparent that the task of creating the model was
viewed as extra work rather than as a part of the knowledge building process for the
team.
There were four issues identified relating to the difficulty of creating the model: 1) The clarity of the instructions given to participants 2) the format used to create the model 3) the difficulty inherent in the task of identifying and representing all the necessary elements for the model and 4) prior experience with modeling.

1) All of the participants thought that the instructions were clear and did not affect their performance. Also, participants stated that they felt able to ask for help at any time in the process of constructing the models.

2) Participants were not restricted in the format they chose for their models; they could be done manually or using any preferred computer software. Only one participant had access to software specifically designed to construct the necessary structure. Of the remaining four participants, one drew the model manually and the rest used word processing software. With the exception of the participant with access to the modeling software, all participants commented on the difficult and time consuming process of creating a fairly complex graphic with inadequate software.

3) The most difficult aspect of creating the model was the task of identifying and relating all the necessary elements. All the participants mentioned the difficulty of the analyzing the project in terms of the model. One participant commented that "I found them
[models] really difficult to use. I found it really hard to figure out what the relationships were between the different factors. I think that it's another layer adding on to the work involved and its time consuming.

4) Another factor linked to the difficulty of creating the models was experience with modeling. None of the participants had any prior experience with conceptual modeling. However, all participants were well acquainted with literature on concept maps and drew parallels between the two. Equating concept maps with conceptual models may have interfered with the use of appropriate modeling structure.

Participants were asked to "explain how you understand the difference between concept maps and conceptual models?" There were very mixed responses to this question. Comments included "the content area is different. A concept map is a map of the conceptual domain and this is a map of the action, practice, the doing...a particular domain of action. And technically I think there are more different things that you're trying to put together". Another participant stated, "I don't think that I really understand the difference". The lack of clear differentiation of the purpose and structure of concept maps and conceptual models may have contributed to the fact that participants did not use the complete modeling framework.
The models themselves were evaluated based on whether they were constructed using all the modeling components. Table 1 shows each participant's use of the predefined elements of the model. It's clear from the chart that none of the models were complete and that most lacked at least half of the necessary elements for a complete model.

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
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<td>✗</td>
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<td>✗</td>
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</tr>
</tbody>
</table>

**Table 1. Participants' use of the modeling components for the individual model**

In order to assess the possibility that the model did not have the appropriate components to represent the project, participants were asked if they "were happy with the components
of the model they were given?", all participants indicated that they would not have changed any of the components of the model.

6.2.2 Creating the Collaborative Model

All the participants agreed that the process of collaboratively constructing the group model was very helpful for the project. One participant commented that "I thought that meeting we had, the group meeting on constructing that big map, I thought that was quite useful. It stimulated us to sort of think about what were the hard goals and what were the soft-goals and how we were going to get from one to the other. So I did think that was a useful exercise." Another participant stated that "I thought the real success was when we all got together with our little models and were able to discuss them, I thought that was really a good session and for communication purposes it was great, it was worth the time to try and make clear what was going on". Overall, there was consensus that the process of creating the model was a positive experience.

One concern was that the model created contained only four of the predefined components. Table 2 shows the components used in the group model.
Table 2 Participants' use of the modeling components for the group model.

During the final interview, participants were asked if they felt "that the collaborative model developed in the project more closely resembled a concept map or a semantic model?". Some participants said it was a concept map, some said it was a conceptual model, others said it was mixed and one stated that "I don't know what I would call it, but it didn't seem to me exactly what I would have thought based on what you had in your instructions".


6.3.1 Individual Model

Apart from evaluating the task of creating the models, it was important to determine if the use of conceptual modeling was successful as a tool for knowledge management and knowledge creation. The individual models were intended to help participants organize,
represent and communicate their thoughts. Their success was evaluated through questionnaire and interview questions.

1) **Did the model effectively express participants understanding of their work?**

On the questionnaire, participants were asked “Did you feel your semantic model effectively expressed your understanding of the project?” there was a very mixed response. One participant did not complete the model at all, feeling that goals for the project were not clear. Conversely, another participant felt that his/her model very effectively reflected understanding for the project. Other participants commented that modeling was too time consuming and cumbersome to effectively express their understanding. Additionally, one participant found the graphical nature of the task to be problematic, expressing that he/she does not conceptualize problems in a graphical manner. Two participants commented that conceptual modeling placed limitations on their ability to express their understanding. Specifically, they felt that models are too “fixed and concrete rather than flexible and evolving” and also that models are “unable to account for emergent goals”.

Some interesting issues emerged from these questionnaire results. First, the issue of whose responsibility it was to identify the goals for the project. This was interesting because if members felt that they were not responsible for defining goals, this may have
contributed to the difficulties encountered when attempting to create a model. In fact, one participant did not complete the individual model at all, feeling that the goals for the project were not clear and not feeling he/she was in a position to clarify them. In order to investigate this issue, participants were asked "who do you believe is responsible for defining the goals of the database project?". The majority of the responses indicated that team members felt that it was their responsibility to develop goals for the project. Comments included, "I think that its clear that the members of the team should be trying to be self directed in making this work" and "well, in this particular project, I thought that it was the members of the team". One participant said, "Well I think that the big goals, [the supervisor] should be deciding that. I think people have different roles to play."

2) Did the model help participants reflect on the problem?

Participants were asked if the felt that the “model helped you reflect on your understanding of the project?”. Participants responded that the exercise helped them “go back and rethink what they were doing and why” and also helped them realize that the goals of the project were not well formulated and that their own understanding of the project was limited. However, one participant wrote that the reflection was a result of being forced to sit and think about the project rather than a direct result of the modeling exercise itself. During the interviews, one participant commented that "I think it was useful. I don't know if it was particularly the conceptual modeling or if it was just the
activity of thinking about the project in a different way. So I guess it could have been another kind of activity that could have resulted in the same analysis."

3) Did participants feel their model could communicate their understanding?

Participants in the study had a wide range of responses when asked if they felt that their model could effectively communicate their understanding of the project to other team members. One participant commented that the effectiveness of a model as a communication tool would depend on individual thinking style. Other participants commented that the model was incomplete and confusing and therefore could not be used to conceptualize the project accurately. Another participant felt that the effectiveness of modeling as a means of communication depended directly on individual past experience with modeling. Finally, one participant commented that the representation, while limited, was public and therefore a good communication aid.

6.3.2 Comparing the Individual and Collaborative Models

Each individual model was expected to represent each team member's perspective of the database project. As discussed previously, members had difficulties with the modeling task. However, despite the problems, during the meeting scheduled for the creation of the group model, individual models were used as references within the larger scope of the discussion. In order to better understand how the collaborative goals were developed, a
comparison was conducted examining the relationship between each individual model and the collaborative model.

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
</tr>
</thead>
<tbody>
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<td>5</td>
</tr>
</tbody>
</table>

Table 3 A goal analysis of individual models compared to the group model.

Table 3 show that some goals from every individual model were included within the collaborative framework. Moreover, out of the 20 goals in the collaborative model, only 4 were not included in any of the individual models. These results seem to show that the individual models were at least partially representative of the agreed upon goals of the project. Furthermore, the collaborative model was quite heavily influenced by the content of each individual model. Assuming that the group model was an accurate reflection of the consensus of the team, this result indicates that the goals represented in the individual models were a fair representation of all the relevant potential goals of the project.
In order to address the validity of the group model as a representation of the group goals, at the end of the group session, participants were asked if they were satisfied with the model they had produced. All participants were comfortable that the model was a fair compromise and was an accurate representation of their thoughts up until the point of the meeting. However, participants did comment that the model was not complete and would require elaboration and refinement as the project progressed. In order to address this issue, the model was placed within the database project view as a dynamic structure.

6.3.3 The Collaborative Model

The group model was implemented within the database project view in Knowledge Forum. There was an attempt to make the model a dynamic structure rather than a static diagram by using scaffold supports in order to allow users to continuously evolve the model. However, when the ATK was used to analyze the database it showed that only seven notes were contributed over the seven-week period of the study, and only one note used the new scaffolds introduced. When the analysis was extended over the course of four months, out of a total of seventeen notes contributed, only three used any of the new scaffolds.

There were a number of possible reasons for the lack of participation in the view. One possibility was that the view itself did not reflect ongoing activity in the project.
However, when asked "how well do you think the database project view reflects the work of the database project?", all participants agreed that the view was an accurate representation of their progress. Another issue was time. As mentioned previously, the amount of time spent on the project over the seven-week period during which study was being conducted was minimal due to a number of different factors. One participant commented that "my general feeling about this view is that I just haven't had the time to work on it. It's just never quite come to the top of my list and every time it gets near the top something comes up and I don't get time to work on it.".

An additional issue was that some participants felt that imposing a rigid goal structure on the view interfered with the existing view structure and organization. Comments included, "its not clear to me that making goals explicit in that way pushes the project forward", "I just think there's a basic problem in clarifying the goals outside of the context of actually working on them" and "I'm concerned about this imposing of fixed goals on something that is more fluid".

6.4 ATK Analysis

In order to better understand the functioning of the database project, the ATK was used to create a profile of team member activity. Over the seven-week period, from the point
where the collaborative model was placed in the view up until the end of the study, there was very little activity taking place within the database project. Table 5 shows a Basic Knowledge Building Measures and Use of features analysis during the seven-week period. Only seven notes were contributed to the view during that time. Note reading activity was variable across the group, and there was almost no use of the knowledge building supports available in Knowledge Forum.

Table 5 Analysis from the database project view over the seven-week period
A key observation was that scaffolds were only used three times within the entire seven-week period. Only one participant made use of the new scaffolds, using the "existing goal(s) this note relates to" and "positive interaction" scaffolds in a single note.

In order to put these results in context the same analysis was conducted on the database project view from the inception of the project right up until the collaborative model was introduced.

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**Profile:**

- **Basic**
- **Knowledge**
- **Building**
- **Measures**

**Time Period:** Notes contributed from October 18, 2000 to May 7, 2001

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**Profile:**

**Use of Features**

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<th># of references in notes</th>
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<tr>
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</tr>
<tr>
<td>Participant 4</td>
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<td>77</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>3</td>
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</tr>
</tbody>
</table>

**Table 6** Analysis of the database project view for the period before the study
Table 6 shows that prior to the study there was quite a bit more knowledge building activity taking place within the view. In particular, participants were reading most of the notes in the view, a high percentage of notes were linked and there were significant uses of the rise-above, reference and scaffold features.

When asked to explain the lack of activity in the view during the study period, participants indicated that the project had been relegated to lower priority during that time.

(\textbf{Number of views} = 232)

\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
\textbf{Profile:} & \textbf{Basic} & \textbf{Knowledge} & \textbf{Building} & \textbf{Measures} \\
\textbf{Time Period:} & Notes contributed from May 8, 2001 to June 28, 2001 & & & \\
\hline
\textbf{User name} & \# of notes created & \% of notes linked & \% notes w/ keywords & \# of views worked in & \# of problems worked on & \% of notes read & \# of revisions \\
\hline
Participant 1 & 20 & 55\% & 0\% & 2 & 0 & 33\% & 51 \\
Participant 5 & 34 & 21\% & 0\% & 6 & 0 & 30\% & 56 \\
Participant 2 & 50 & 50\% & 0\% & 12 & 3 & 73\% & 33 \\
Participant 6 & 3 & 0\% & 33\% & 3 & 1 & 14\% & 0 \\
Participant 3 & 4 & 75\% & 0\% & 3 & 0 & 23\% & 0 \\
Participant 4 & 12 & 0\% & 58\% & 6 & 9 & 9\% & 4 \\
\hline
\end{tabular}

<table>
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<th>\textbf{User name}</th>
<th>\textbf{Use of Features}</th>
<th>\textbf{User name}</th>
<th>\textbf{Use of Features}</th>
<th>\textbf{User name}</th>
<th>\textbf{Use of Features}</th>
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<th>\textbf{Use of Features}</th>
<th>\textbf{User name}</th>
<th>\textbf{Use of Features}</th>
</tr>
</thead>
</table>
| \hline
| User name & \# of notes in build-ons & \# of keywords in notes & \# of references in notes & \# of rise above notes created & \# of scaffold supports used & \# of annotations | \hline
| Participant 1 & 4 & 0 & 7 & 0 & 5 & 0 & 16 |
| Participant 5 & 3 & 0 & 2 & 3 & 28 & 0 & 9 |
| Participant 2 & 16 & 0 & 27 & 1 & 17 & 0 & 31 |
| Participant 6 & 0 & 3 & 0 & 2 & 0 & 0 & 0 |
| Participant 3 & 2 & 0 & 2 & 0 & 22 & 0 & 3 |
| Participant 4 & 0 & 15 & 0 & 0 & 1 & 0 & 6 |
| \hline

\textbf{Table 7 Analysis on remaining KBShare views over the seven-week period}
In order to further assess this issue, the same ATK analysis was conducted on the remaining views within the KBShare database during the course of the project. It was expected that participants would be much more active in other, higher priority, views. Table 7 confirms this hypothesis. One interesting result is that there were no scaffold supports used at all by the participants within the remainder of the KBShare database. This finding helps clarify some of the issues surrounding the failed implementation of the collaborative model as a dynamic structure within the database. The functioning of the structure was dependent on the use of scaffold supports. However, it appears that scaffold supports were not widely used by participants in any of the views they participated in. Initially, it was assumed that asking participants to use scaffolds within the project fit within their current use of scaffolds. However, this was clearly not the case and may have contributed to the problems encountered implementing the dynamic structure. It should be noted, however, that Knowledge Forum scaffolds have been used quite successfully in other contexts, and so the problem is not with scaffolds per se.

7 Discussion and Conclusions

7.1 Facets of Knowledge Creation

Community knowledge, rise above, improvable ideas and symmetric knowledge advance are the four facets identified as crucial for knowledge building within organizations. In
order to best understand the successes and failures of this study, it is useful to place results within this context;

1. Community Knowledge

The construction of conceptual models to act as external, explicit representations of individual and group understanding is clearly consistent with the principle of community knowledge. Ideas must be shared and exchanged and conceptual models provide a potential language for facilitating these processes. Furthermore, placing the co-constructed model within the database project view added an additional and powerful community knowledge support to Knowledge Forum.

The ATK results showed that the community knowledge supports available within Knowledge Forum, such as build-ons, references, and annotations were not in significant use over the course of the project. In order to better understand how conceptual modeling can be effectively used within Knowledge Forum, ideally all community knowledge supports should be used together with the model. This did not take place within this study, but poses an interesting question for further research.

It should be noted that it is possible to use a manager conceptual model as a background within a view rather than adopting the team construction process that was used for this
study. Perhaps a manager constructed design would have provided a more effective community knowledge building support, assuming that the structure was dynamic and changeable, allowing evolution of ideas and emergent goals.

2. Rise-Above

Rise-above requires that problem solving and conflict resolution continuously result in progressively higher levels of analysis and activity. The structure of the conceptual models used in this study demanded that participants engage in rise-above thinking. Sub-goals represented the refinement of goals and the modeling structure was intended to encourage participants to link activities or events to a given goal. Elaboration of goals and linking them to a concrete context is both fundamental to rise-above thinking and to the effective use of the conceptual modeling framework borrowed from EXIP.

The most obvious example of the rise-above principle at work was the development of goals and subgoals used in the models from the rather abstract purpose statement shown in Fig. 6. However, because no participants used the complete modeling framework, the extent of the rise-above activity was limited.

Rise-above also requires that emergent goals be accommodated. Most knowledge management software, such as EXIP, deals with a set of static goals and does not allow the user to elaborate them over time. Knowledge Forum enables users to easily represent
emergent goals and has supports in place to facilitate this process, including the rise-above tool and scaffolds. Additionally, views within Knowledge Forum can be linked and re-structured, creating increasingly higher-order and comprehensive networks of views. However, as the ATK analysis showed, participants did not make significant use of these supports. Furthermore, attempts to make the collaborative model a dynamic structure within the Knowledge Forum environment were unsuccessful. Future research should be conducted to attempt to more effectively construct a dynamic model and implement it within the Knowledge Forum environment.

3. Improvable Ideas

Improvable ideas are central to knowledge creation. While information management provides solutions for organizing and structuring ideas, if ideas are not changing and improving, knowledge building is not taking place. The individual modeling framework used was designed to enable the team to explicitly represent and elaborate ideas. Specifically, soft-goals were introduced to better enable participants to represent the ill-defined problems they were facing. The hope was that by transforming ideas into external artifacts, participants would find them easier to manipulate and improve upon. However, the difficulties participants encountered while using the modeling framework acted as a barrier to effective use of the models. The results showed that the modeling task was seen as extraneous and not effectively incorporated into the daily knowledge
work of the team members. This finding illustrates the need for knowledge building tools to be easily assimilated into the daily functioning of an organization.

4. Symmetric Knowledge Advance

Knowledge building cannot advance with static structures. Progress in one area of work should create progress in other areas. Advances of one member should facilitate the advances of other members. Essentially, there should be symmetry in any system of knowledge flow, not simply one group informing another. Dynamic structures are necessary to enable this type of knowledge building. The most serious design flaw within the EXIP modeling framework used in this study was the lack of dynamic structure.

The database project represented an ill-defined task and as such the progress of the team depended on the symmetrical building and refining of goals as each individual contributed their own expertise to the group. This was clear during the group meeting where each participant referenced their own model while constructing the group model. Table 3 shows that while goals from each individual model were incorporated into the group model, each participant had quite a few additional goals that were not included. This result nicely demonstrates the process of progressively bringing together a smaller, more refined set of goals for further elaboration.
7.2 Conclusions

At the end of the project, participants were asked if they "considered using conceptual models helpful, neutral or detrimental to the project?" Most participants responded that they found the exercise neutral. However, one participant found it detrimental stating "I don't think we got enough payback for the time we put into it and this imposition of goals on a space that was otherwise okay." Conversely, another participant stated that "I found it helpful. Unqualified". Based on these results it is difficult to draw any definitive conclusions about how participants viewed their experience with conceptual modeling. Additionally, the size and scope of a case study limit the conclusiveness of this type of investigation. However, there are a number of general observations and conclusions that can be drawn.

First, if modeling is to be used as a tool for knowledge management, the task of creating the model cannot be segregated from the work itself. Most participants viewed time used to create their model as time away from their work. This result indicates quite clearly that this study failed to convince most of the participants involved that the task of creating a model could be a valuable part of their work. It is vital that the tools used to enable
effective knowledge management be a part of the knowledge building process and not incidental to it.

Second, modeling is a difficult task. There are courses offered at the graduate level specifically oriented towards teaching students how to model effectively. Asking individuals inexperienced in modeling to create a comprehensive model of their work domain may be an unreasonable expectation. If modeling is to be used as a support for knowledge creation, the issue of usability must be addressed. Software such as EXIP must be integrated into the work environment as seamlessly as possible.

Another concern is the static structure of conceptual models. Participants felt that modeling lacked the capability to represent fluid goals and constantly changing goal decompositions. Knowledge creation requires a dynamic environment in order to flourish. This concern can easily be addressed in the future design of systems that incorporate conceptual models. However, in the proposed EXIP modeling framework, there is no discussion of whether the model used should be a static or dynamic structure. This issue is vital in real world settings where goals are not fixed and evaluating the relevance and priority of different goals can be an ongoing process. If models cannot effectively capture this feature of the workplace, their usefulness as a knowledge creation support is limited.
This study attempted to bring together conceptual modeling and Knowledge Forum to investigate conceptual models as tools for knowledge creation and also to determine how incorporating a collaborative conceptual model into Knowledge Forum could strengthen both tools as supports for knowledge creation. The investigation clearly showed that the challenge of merging these two constructs must be viewed as an ongoing design problem. Conceptual modeling proved to be a time consuming and cumbersome form of representation for workers. Implementing the dynamic structure in the view was dependent on knowledge creation supports within Knowledge Forum that the team was not employing. These are design problems that need to be addressed in further research.

There were also issues surrounding the use of the database project for the investigation. The project was devoted to solving a particularly ill-defined problem, members did not have clearly defined roles and the project itself was relegated to low priority due to a number of external factors. These factors contributed to the difficulties participants encountered while trying to formulate goals and also played a role in the lack of activity in the database project view. An active project with more clearly defined goals and roles may be a better setting to investigate the merging of Knowledge Forum and conceptual models.
Perhaps the most successful aspect of the project was the group meeting to co-construct a conceptual model. Participants unanimously found the session helpful and the final product was a fair representation of the group's thinking. This finding nicely illustrated the effectiveness of using conceptual modeling as a community knowledge support. Furthermore, the placement of the model within the view to act as a guideline for future contributions represented an important design advance for Knowledge Forum. This success encourages future efforts to overlay an effective dynamic structure on the collaborative model within the Knowledge Forum environment and strengthens the hypothesis that this type of research may yield very positive knowledge creation results.

Knowledge creation must operate at all levels of an organization and across organizations in order to successfully support innovation. In order for this to happen, tools must be developed to enable and sustain knowledge creation. Knowledge Forum and conceptual modeling represent two potentially powerful knowledge building tools for organizations. More importantly, their merging, under appropriate design conditions presents possibilities for extending the knowledge creation capabilities of both. The current challenge is to design and redesign until the factors that mitigate their efficacy can be identified and addressed.
8 References


9 Appendix

9.1 Instruction handout for Construction of the Individual Models

Components of a Semantic model

The semantic model can be thought of as a network of relationships between goals, sub-goals, events, actors and documents. The components of the model are as follows;

GOAL: A desirable state of affairs. A goal can be decomposed into SUB-GOALS through two types of relationships;

3. AND-relationship relates a goal to a set of sub-goals such that fulfilling all sub-goals is a sufficient condition for the fulfillment of the goal.

6. OR-relationship relates a goal to a set of sub-goals such that fulfilling at least one of the sub-goals is a sufficient condition for the fulfillment of the goal.

For our purposes, goals will include SOFTGOALS. Soft-goals represent ill-defined goals and their interdependencies. Examples of a soft-goal include usability and security.
It is often the case that lateral influences between two goals. Such influences are represented in terms of effect relationships, which can be labeled "+" or "−", depending on the nature of the influence.

Goals are related to EVENTS in several different ways. For our purposes, an event is an occurrence of an activity. Events may cause the fulfillment of a goal, or contribute to the fulfillment of a goal positively or negatively. Events may also serve as road signs which indicate how far from fulfillment is a particular goal. The semantic model describes what types of events are relevant to each goal and how they affect it.

Apart from goals and events, the modeling framework also includes the concept of an ACTOR. An actor is an organizational unit. Actors can be associated with goals through a dependency relationship (satisfying a goal depends on an actor) or through an interest relationship (satisfaction of a goal concerns particularly an actor).

The final component of the model is a DOCUMENT. Documents are classified within three taxonomies respectively. For example, a particular paper or URL is first classified
in the GOALS taxonomy to see if it is relevant to any goals and what the relevant goals are if yes. Then, it is classified within the EVENTS taxonomy to check if it belongs to any relevant event nodes in the model. Finally it is classified within the LINKS taxonomy. For example a document may affect the link between an event and a goal. Documents can be viewed as supporting or refuting evidence for a particular goal, event or link. For our purposes notes in the database can be classified as documents.

9.2 Questionnaire

EVALUATION OF YOUR SEMANTIC MODEL

Do you have any previous experience using semantic models? If yes, please explain.

None | Extensive
-----|-------
1    | 2 3 4 5

Did you feel your semantic model effectively expressed your understanding of the project?

Not at all | Very well
-----------|-------
1 2 3 4 5

Please explain your answer.

Do you feel that the model helped you reflect on your understanding of the project?

Not at all | Very well
-----------|-------
1 2 3 4 5

Please explain.
Do you feel that your model could effectively communicate your perceptions of the project to other team members? Please explain your answer.

<table>
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<th>Not at all</th>
<th>Very well</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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<tr>
<td>3</td>
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Would you have changed any of the components of the model (i.e. goals, sub-goals, actors, events, documents)? If yes, what would you have changed?

9.3 Interview

I would like to understand, based on your experience, the pros and cons of using semantic models. I have questions that I want to ask you, but I also want to hear any thought you have about this—so please feel free to add comments at any time. I would appreciate it if you do not talk with other team member about this until I finish interviewing everyone. I will send an email to you as soon as I am finished with these interviews.

--------

1. Over the last 2 months, how much of your time do you think has been devoted to working on the database project? Is that more or less than the time you committed to this initiative prior to that point? Why the increase and/or decrease?

2. At the beginning of the semantic model study, how did you believe that using semantic models would affect the project?

   - Now, at the end of the project has your opinion changed?

3. What is the most negative aspect of using or contemplating the use of semantic models for this project?

   - Did you find the instructions clear? Confusing?
4. What was the most important insight you gained from your introduction to semantic models in this project?

5. What was the most positive aspect of using or contemplating the use of semantic models for this project?

6. Overall, did you consider using semantic models helpful, neutral, or detrimental to the project? Please explain.

7. Can you explain how you understand the difference between concept maps and semantic models?

   - Do you feel that the model used in this project more closely resembled a concept map or a semantic model?

8. How do you feel that participating in the study may have affected your daily work, if at all?

   - Do you feel that a work environment is an appropriate setting for this type of study? Please explain.

9. Who do you believe is responsible for defining the goals of the database project?

   - Members of the team or the supervisor of the team?

10. How well do you think the Database Project view in KBShare reflects the work of the Database Project?

    - Are the contributions to the view reflective of the amount of work going on outside the view?