Knowledge Management: Why Learning from the Past Is Not Enough!

Rogério dePaula and Gerhard Fischer

Center for LifeLong Learning & Design (L^3D)
http://www.cs.colorado.edu/~l3d
Department of Computer Science and Institute of Cognitive Science
University of Colorado, Boulder

Abstract

Traditional knowledge management (KM) approaches aim to archive information from the past so lessons will not be forgotten, implying that the information needs of the future are expected to be the same as they were in the past. The basic assumption underlying our approach is that knowledge is not a commodity to be consumed but is collaboratively designed and constructed, emphasizing innovation, continuous learning, and collaboration as important processes.

Our approach to KM focuses on a *design perspective* in which workers as stakeholders create new knowledge as they carry out their work practices. Our goal is to enable innovative practices at a social level by supporting collaboration and communication. We see knowledge as an intrinsic aspect of collaborative design practices, in which stakeholders are integrating the knowledge they collaboratively construct into the (re)design of solutions and the practices themselves.

Exploring this approach, our research has studied the design and deployment of a collaborative KM system, Web2gether, which was developed to facilitate the creation and development of social networks among special education professionals. This effort has set the stage for a more systematic and thorough study of the integration of this technology into these professionals' day-to-day work practices. It has enhanced our understanding concerning the issues pertaining to the adoption of Web2gether as a KM system and its effectiveness in addressing its users' real information and support needs.

Keywords

Knowledge as commodity, collaborative knowledge construction, distributed cognition, information ecologies, social networks, design time, use time, access, informed participation, special education, Web2gether, cultural change

Introduction

The traditional approach for knowledge management (KM) often considers knowledge as a commodity (Murray, 2000). An alternative view of KM oriented toward design communities focuses on support for collaboration, communication, and development of social networks (SNs) among stakeholders in design activities.

A discussion on KM cannot be restricted to the epistemological analysis of knowledge or the technical evaluation of a KM system. It has to address the various scales of interaction that impact the work practices of those involved in the processes of introducing and employing new KM practices and systems. Although the underlying definition of knowledge, either as a commodity or as the outcome of a design practice, will influence the design approach for KM practices and systems (see Table 1), a more thorough guideline for design needs to be complemented with a deeper understanding of social, technical, and organizational aspects of the context in which KM is to be employed. These aspects will help in unveiling the opportunities and challenges of the approach.

Toward this end, we have devised a more complete framework for KM based on the *design perspective*. In this framework, knowledge is regarded as being distributed among stakeholders and artifacts, being enacted while they carry out design activities within communities of practices and/or interests. As such, this framework draws on the concepts of distributed cognition, social networks, and information ecologies. A KM system to support this perspective should be based on the design of living organizational memories, which are evolving and collaborative repositories of information. This design approach draws on a process model for evolving and collaborative systems—namely, the seeding, evolutionary growth, reseeding model.

In this chapter, we describe and contrast the two conceptual foundations for KM to set the stage for an empirical study in which the *design perspective* was employed to support the complex and distributed work of special education professionals. This study has helped us further understand the opportunities and challenges in employing such a perspective in a real context. A successful integration of novel KM practices and systems into the work setting required major organizational and social changes, which can be facilitated or hindered by existing organizational structures (such as work, social, and incentive structures). Only through the balance between "the traditions and the transcendences" (Ehn, 1988) will KM ap-

proaches be able to respect these existing structures and at the same time help to enhance these practices with innovations.

The two perspectives outlined in Table 1 serve as the focus of the approach put forth later in this chapter. We start our discussion by describing and comparing the *commodity perspective* and the *design perspective*. Next, we describe our effort to apply the *design perspective* to a major project in which we created a collaborative KM system, Web2gether, to serve the needs of the special education professionals for people with disabilities. Our research has shown the opportunities and pointed to some of the benefits in utilizing this system to support the work of these professionals. We focused on providing them with professional and personal support through the development of social networks. To this end, we designed Web2gether to support the distributed and situated work of special education professionals, by implementing the notion of social network in the core of the system. The *design perspective* is not without challenges. We discuss the lessons learned from our research and development effort, including some challenges in deploying Web2gether.

Table 1: Two Perspectives of KM (Fischer and Ostwald, 2001).

	Commodity Perspective	Design Perspective
Nature of Knowledge	Object	Enacted
Creation	Specialists	Stakeholders
Integration	Design time	Use time
Tasks	System-driven	User-driven
Learning	Transferred	Constructed
Dissemination	Broadcasting	On-demand
Technologies	Closed, static	Open, dynamic
Work Style	Standardized	Improvised
Social Structures	Top-down	Peer-to-peer
Work Structures	Hierarchical	CoP and CoI
Incentive Structures	Job assignments	Direct involvement
Breakdowns	Errors to be avoided	Opportunities

Two Perspectives on KM

In the traditional views of KM, knowledge is regarded as a commodity that needs to be captured, stored, and indexed to allow efficient retrievals in the future. The underlying assumption is that future needs are most likely to be the same as those of today. The responsibility for creating adequate "knowledge structures" to enable future retrievals from the shared repository of "knowledge objects" is delegated to specialists (e.g., knowledge engineers), who at *design time* (when a KM system is designed and developed) create such structures.

Our work is grounded on a design perspective of KM that supports a design culture in which collaborating, working, learning, and creating knowledge are complementary aspects of the same social practice. From this perspective, knowledge does not reside inside one's head, but is distributed in a network of stakeholders and artifacts, and collaboratively constructed and enacted as work situations unfold. Stakeholders are reflective practitioners (Schön, 1983), who struggle to understand and solve ill-defined problems. Learning is intrinsic to problem solving because problems are not given but must be framed and solved as unique instances. Knowing in action provides a rich interpretive framework for individuals to cope with these new situations. As Schön put it, "our knowing is in our actions" (ibid, p. 49).

This perspective has two essential aspects. First, stakeholders, not specialists, create knowledge. Knowledge is an intrinsic aspect of acting in practice and is created by those who own the problems as they emerge (Fischer, 1994). Second, knowledge is a collaborative by-product of work. By actively participating, stakeholders become "knowers," and by collaborating, they construct knowledge. These aspects are summarized in Table 1, which contrasts the traditional "commodity perspective" of KM with the "design perspective."

From our perspective knowledge should not be treated as an object created, integrated, and stored by knowledge specialists at *design time*, to be later manipulated, transferred, and retrieved by users at *use time* (when the KM system is deployed and used), when they encounter problems and knowledge becomes necessary. It is instead one of the by-products of getting work accomplished, as enacted in collaborative practices by a network of stakeholders. In this network, these stakeholders, such as engineers, architects, government representatives, and local citizens, engage in the design of a joint solution to a common problem, and collaboratively constructing the knowledge necessary to address the problem at hand.

Knowledge is integrated into potential solutions at *use time* by means of user-driven tasks, rather than being predefined at *design time* through a series of canonical (system-driven) tasks. In light of that, the design process considers learning as a process of knowledge construction acquired as stakeholders act and improvise while carrying out their activities. In contrast, the commodity perspective regards learning as the transfer of knowledge from the "knowers" to the "learners." Knowledge is *broadcast* to an audience through standardized tasks, rather than being activated *on-demand*.

These two perspectives emerge from and support two distinct organizational structures. Knowledge as a commodity rests on top-down social structures in which there is a clear distinction between those who create the knowledge and those who need and use it. From the design perspective, no clear line exists between these two groups in that those who own the problem and need the knowledge are the ones who help to create it and later integrate it into the solutions. The top-down structure often reflects the hierarchical structures of roles and power of work structures, whereas the peer-to-peer structure reflects the types of work structures that take place in communities of practice (CoPs) (Wenger, 1998) and communities of interest (CoIs) (Fischer, 2001).

Another relevant implication of a top-down approach pertains to the incentive structures required to maintain the ongoing processes of creating and integrating knowledge as practices distinct from problem solving. This approach thus fosters a discrepancy between who does the work and who benefits (Grudin, 1988). This requires formal reward systems in organizations to motivate the process, such as mandatory and/or paid job assignments. In contrast, in a bottom-up approach, the incentive structures are often inherent from the collaborative structures of CoP and CoI. Stakeholders in this approach are more likely to actively participate due to their direct involvement with and ownership of the problems at hand.

The design of a technology to support either perspective carries with it certain implications. The commodity perspective rests on the premise that knowledge will be acquired, indexed, and stored at *design time* to address problems at *use time*. This implies the design of a closed system whereby information is preprocessed by knowledge engineers before the users of the system can make use of it. In contrast, the *design perspective* is grounded on the premise that knowledge is enacted in practice, and that stakeholders will activate the necessary other networks, information sources, and technologies so they can address their situated needs.

Traditional Views of Knowledge

In the 1990s, a major strategic shift took place in organizations with the acceleration of the rate of political, economic, and technical changes as well as the increasing worldwide use of information and communication technologies. At the same time that such changes were paving the road for a global market, globalization reciprocally helped to accelerate them. The new tendencies of this "information economy" required organizations to shift from simply thinking about products and marketplaces to focusing on resources, human capacities, and core competencies. The ability to outperform the marketplace rested on continuous generation of human capital, "generation and synthesis of collective, and organizational knowledge" (Brown and Duguid, 1998, p. 91). Particular attention was given to the challenges and opportunities of sharing and transferring knowledge within and across organizations. This became the major tenet and driving force of the traditional KM paradigm, which assumes that experiences lived in the past should not be forgotten in order to inform future experiences. Knowledge required and created thereof is deemed as a stock or resource to be captured, codified, archived, transferred, and disseminated, i.e. as currency.

The major approaches to address the challenges posed by this view take a "taxonomic" (Tsoukas, 1996) perspective. Such a perspective attempts to classify different "types of knowledge" in different organizations, which supposedly would create effective means for generating, sharing, and managing knowledge (Orlinkowski, 2002). Many classifications stem from and elaborate on the distinction made by Polanyi (Polanyi, 1966) between tacit knowledge and explicit knowledge. Other dichotomies associated with knowledge were thereafter elaborated, such as codified versus noncodified knowledge (Hansen, 2002); "know-how" versus "know-what" (Brown and Duguid, 1998); and procedural versus declarative knowledge. They represent important, yet limited attempts to explain how *knowers* know (or learn) what they know (or need to know) to accomplish their tasks.

Explicit knowledge is commonly portrayed as simply codified or codifiable knowledge. As such, knowledge is treated as information, or "know-what," which can be reified and thereby captured, codified, and archived for future reference, and often is removed from the context in which it was generated. In contrast, *tacit knowledge* is usually discussed as personal, non-articulated, experience-based, and skill-type bodily knowledge (Polanyi, 1966). It can be thought of as a latent ability, often acquired through experience that can be enacted and activated in the context of work practices. As such, tacit knowledge contains subjective elements that

make it more difficult to articulate, and it embeds elements of a particular practice that makes it difficult to transfer from one practice to another, thus making it "sticky." It is distributed among stakeholders, artifacts, and the social environment, which together with norms, division of labor, and motives constitute the activities of a CoP or a CoI.

A purely taxonomic view of knowledge poses intractable difficulties to the design of KM systems. The articulation and (de)contextualization of tacit knowledge are widely debated, yet unsolved problems. Due to the nature of *tacit knowledge*, namely being based on experiences derived from actions and interactions in a context, it emerges from a practice and can not be always associated with a specific element that constitutes it. Because *tacit* and *explicit knowledge* are mutually constituted and thereby are *sui generis* (Brown and Duguid, 1998), the transferring of knowledge from one practice to another becomes inherently problematic. There is a need for KM researchers and practitioners to go beyond the dichotomies. Knowledge should instead be seen as the ability to enact knowledgeably in practice (Orlinkowski, 2002), as "know-how" integrated with "know-what" in practice, and as an emerging, often distributed, property of these practices.

These dichotomies have led to a narrow view of knowledge, organizational knowledge, and knowledge management. Knowledge has been regarded as a stock or a thing that somehow needs to become explicit so that it can be shared among stakeholders within and across organization boundaries. It fails to recognize that *tacit* and *explicit knowledge* are mutually constituted (Tsoukas, 1996) and cannot (and should not) be detangled from the practice from which they emerged. In particular, this view has led to two problematic notions of knowledge and the approaches to knowledge, namely, *knowledge of the past* and *knowledge as commodity*.

Knowledge of the Past

> *"Those who cannot remember the past are condemned to repeat it."* (*George Santayana*)

The quote from George Santayana reflects the underlying assumptions pertaining to the traditional approaches for KM. The major goal is to archive "knowledge" from the past so that lessons will not be forgotten. This is a rather limiting view of KM because it implies that the information needs of the future will necessarily be the same as they were in the past. Subsequently, those who need information for the problem at hand are treated as simply passive consumers of information (Fischer, 2002).

Knowledge of the past represents an attempt to articulate knowledge gained from previous experiences in order to anticipate future problems and to inform future actions. In organizations, it takes the form of best practices, scenarios, technical and directive documents, and reports that are generated by specialists based on previous experiences as well as anticipated and interpreted future needs. The goal is to provide efficient ways for users to access and share such explicit knowledge, although it alone is most likely to be insufficient to help in solving the problem at hand. Two distinct problems thus arise from this view. One is the assumption that this static and somewhat limited notion of knowledge can handle the complex and dynamic nature of real-life problems. The other is that it relies on existing understandings of the work practices it intends to support (Orr, 1990) and on imaginative limits of those who create it (Snowden, 1998).

In analyzing the effectiveness of formal documents in supporting everyday practices, Orr (1990) asserts that directive documentations are "designed not to enable deduction but to direct technicians to the solution through a minimal decision tree" (p.171). The premise is that the most effective sequence of actions can be determined at *design time* by developers and knowledge engineers who have a strong understanding of the technologies they develop but are likely to have a limited understanding of the context wherein such technologies are used. Not only do they have to anticipate possible problems with the technology, possible diagnoses, and efficient paths to the solution, but they also assume that the problems technicians will face in the field and the instructions to solve them are context-free, due exclusively to technical mishaps. Orr shows the extent to which this approach alone has been elusive and ineffective. He argues instead that users' most important goal is not necessarily to "fix a machine," but rather the relationship between the clients and their machines, and their relationships with the clients—in other words, "to keep clients happy" (ibid, p. 172).

Knowledge of the past is thus useful to the extent that it can anticipate future needs and be transferred across different contexts. It involves the articulation and organization of possible states and needs that can be anticipated at *design time* to address problems at *use time*. Hence, it constitutes a closed system. The "closedness" refers to the fact that the underlying sociotechnical structures of such systems are determined at *design time* and are unlikely to be modified at *use time* by the users. *Closed systems* do not give ownership to those who own the problem, but to a selected group of designers whose major challenge is to foresee all possible tasks and breakdowns in order to store answers to questions that might arise thereafter. These systems are likely to contain information that is chronically

out of date and reflects an outsider's view of the work (Brown and Duguid, 2000).

Closed systems often limit the communication channels between those who own (or have mastered) the (sociotechnical) artifacts and those who own the problem (Fischer, 1994). In real work settings, stakeholders may not restrict their actions to those anticipated by a directive documentation (Orr, 1990), but their achievements and their innovative actions would unlikely be shared with other members of their work community via the "official channels." Innovation will likely happen outside the system. The sharing of innovations, "know-how," and successful work experiences—war stories—often takes unexpected pathways. Orr (Orr, 1996) revealed that, due to the absence of information or difficulties in interpreting the directives in the documentations, technicians expect to learn from one another, and, despite the individual character of their work, they make the effort to meet each other and to share their "war stories."

Knowledge as Commodity

> *"Knowledge is presented as a commodity to be acquired, never as a human struggle to understand, to overcome falsity, to stumble towards the truth." (Postman, 1995, p.116)*

From an economic standpoint, the simple idea of being able to stock knowledge as a disembodied asset belonging to the organization was compelling enough for managers to open-heartedly embrace the KM vogue of the 1990s. From a technical perspective, the idea of manipulating knowledge as information was embraced as the solution for the challenges posed by the information economy in the information age. The emphasis on knowledge in organization has encouraged studies on the nature of knowledge that yielded the re-conceptualization of the firm as a dynamic knowledge-based activity system (Spender, 1996). The superficial and naïve implementation of KM approaches, resting on knowledge as a commodity, resulted in a blind emphasis on knowledge-based systems at the cost of deemphasizing knowledge as an attribute of people (Brown and Duguid, 2000).

The commodity perspective reifies "knowledge as a stock or set of discrete elements" (Orlinkowski, 2002, p. 250). Studies based on the distinction between codified and noncodified knowledge (Hansen, 2002) exploit the underlying assumption that the major difficulty of transferring knowledge hinges on the difficulty of representing it. They show that the strength

of the relations between knowledge seekers and knowledge providers affects the likelihood of "noncodified" knowledge being transferred. Although these studies have offered this important insight concerning the importance of *social ties* (both weak and strong) between those who own the problem and those who have the knowledge, they failed to provide a richer account for the nature of knowledge. They basically treated knowledge as information.

The Fallacies of Traditional Knowledge Management

The traditional approaches for KM, which have mistaken knowledge for information and a commodity, can be costly. Brown and Duguid (2000) tell a story of a firm that spent a generous amount to take over a rival, primarily in order to capture this firm's impressive intellectual capital, only to finally realize that its real competitive advantage had "lain in the operating knowledge of its line employees, all of whom had been let go" (p. 122). Similarly, the somewhat blind notion that KM would allow firms to downsize their "expensive" staff by process reengineering, which has instead caused them to lose human capital and its collective knowledge, instrumental for their operations. As John Thomas (Thomas, 2001) put it:

> *It is a myth that we can simply "capture" the knowledge of a thirty-year expert in explicit form so we can fire the expert and hire someone with no relevant skills off the street, who can now use the "knowledge base" to perform like an expert.*

At the surface, it seems natural to use knowledge and information interchangeably, but there are significant social and technical implications in doing so. Information can be treated as a self-contained element that can be manipulated, stored, and retrieved, whereas knowledge entails a knower (Brown and Duguid, 2000) knowledgeably acting in practice (Orlinkowski, 2002). The focus shifts from studying only "what" people hold and share and the suitable technologies for doing so toward studying of the processes whereby *motivated* actors become knowledgeable and share their "knowing how" in practice and the suitable social and technical contexts for doing so.

Simply designing so that experiences of the past will not be forgotten in the future is insufficient to adequately address the current (and future) challenges of our society. Such an approach emphasizes information needs, although the major challenge nowadays can be characterized as *information overload*. Designing for "anytime and anywhere" is not as rele-

vant as designing to "say the right thing at the right time in the right way" (Fischer and Ostwald, 2002a). KM should be designed to support evolution and implement *meta-design* principles (Fischer and Scharff, 2000) to support a design culture.

Design Perspective: Social and Situated Views of KM

The greatest contribution of the Internet was not necessarily to facilitate *reach* (easy access to information) but to facilitate *reciprocity* (social exchange worldwide) (Brown and Duguid, 1998). Similarly, the *design perspective* for KM goes beyond *reach* to allow *reciprocity*. It recognizes the key role of human agency in knowledgeable performances (Orlinkowski, 2002), which are processes by which stakeholders are capable of knowledgeably acting in practices and thereby making appropriate and informed decisions concerning a problem at hand.

Knowledge is often portrayed as a possession that people carry around in their heads and transfer to each other, despite the fact that work is unlikely to be carried out in isolation, let alone without the aid of external artifacts. In contrast, we see *knowing* as mediated by artifacts situated, and often distributed, in the social environment (Salomon, 1993). Knowledge then becomes people's ability to act, participate, and make appropriate and informed decisions. Knowledge thus emerges from the synergy (rather than the synthesis) of distributed social networks of stakeholders and artifacts, operating in concert to help each other accomplish a common goal. It is no longer held or possessed, but fluid, distributed, and "activated." It focuses on the role of human agency in enabling the work to get accomplished in the context of a *design practice* within a CoP or CoI.

Due to the complex nature of social settings in which knowledge is enacted, it is critical to understand the various aspects that contribute to the formation of the *sociotechnical conditions* for stakeholders to accomplish their work, instead of focusing solely on the knowledge-transferring problem. To this end, we propose a conceptual framework to understand the sociotechnical conditions at *design time* as well as at *use time*. This framework attempts to guide the design of KM systems by highlighting the distributed and collaborative nature of design practices, and to help in the analyses of organizational issues that may facilitate or hinder the use of such systems. This framework draws on the following concepts:

- **Communities of Practice and Interest**: Design contexts in which the design perspective on KM emerges.
- **Distributed Cognition**: Knowledge distributed in the environment.

- **Social Networks**: Knowledge as a property of the interactions and relationships among stakeholders and artifacts.
- **Information Ecologies**: Complex, coordinated, dynamic, and dependable relationships among actors and information sources.
- **Living Organizational Memories**: Design rationale for the evolving KM system to support social networks.

Communities of Practice

The inherently social and situated nature of knowing invites us to consider a meaningful social structure in which knowledge is enacted, created, and shared among stakeholders. Such a structure should represent the social and historical contexts in which they are capable of acting, participating, and making appropriate and informed decisions. Social practice represents an important sociocultural structure that embraces most of these aspects. Through practice, members of a sociocultural community develop a shared understanding of what they do, how they do it, and how they are related to each other and to other communities and their practices.

Because individuals often work in collective settings, and knowledge is distributed among practitioners and their social environments, social practice was broadened to account for the relationships among these individuals within their working communities. Lave and Wenger (1991) define a CoP as a social structure that captures the interdependence and relationship among individuals, (legitimate) participation, communities, and sociocultural practices. A CoP creates the conditions for its members to exercise their ability to put their knowledge into practice (Wenger, 1998).

The ability to knowledgeably act in practice often is different from the "official knowledge" specified in manuals, directive documentations, and best practices. It emerges from experience and, more important, active participation in CoPs. For example, Orr (1996) shows that technicians must first learn about the work and the social settings, including the technology, in which services occur so as to tackle the actual sources of the problems, which in most cases are not necessarily technical. Such knowledge to act in practice can be acquired only through participation and experience, and mostly shared among members of the same community of practice.

Despite the informal aspect in most of organizations, CoPs are often very stable social structures. CoPs have histories, cultural identities, interdependences among members, and mechanisms for reproduction (Lave and Wenger, 1991). Such stability enables the development of trust, shared language, strong social ties, and common values, which facilitate the crea-

tion and dissemination of knowledge among the members of CoPs. Although CoPs are a powerful source of knowledge, they can easily be restricted by the limitations of their own world-view, that is, the risk of *group-think*.

Communities of Interest

Working on complex problems usually requires the collaboration and coordination of stakeholders from different CoPs. We define a CoI (Fischer, 2001) as a group of stakeholders brought together from different CoP, on the basis of a common concern or interest, to solve a particular complex design problem. They can be thought of as "communities-of-communities" that help CoPs to overcome the problems they create for themselves. In contrast to project teams, wherein employees are held together by a formal contract such as a business project, CoI stakeholders are held together by a shared interest. There are fundamental differences in their goals and motivations.

CoIs are often more temporary than CoPs and do not establish a social practice. They are characterized by a shared interest in the framing and resolution of a design problem and can be more innovative and more transforming than CoPs if they can leverage on the "symmetry of ignorance" (Rittel, 1984) as a source of collective creative innovations. Challenges facing CoIs are in building a shared understanding of the problem at hand, which often does not exist at the beginning but evolves incrementally and collaboratively. Members of CoIs must learn to communicate with and learn from each other (Engeström, 2001), although they may have different perspectives and perhaps different vocabularies for describing their ideas. Learning within CoIs is more complex and multi-faceted than *legitimate peripheral participation* (Lave and Wenger, 1991) in CoPs, which assumes that there is a single knowledge system within which newcomers move toward the center over time.

Because CoPs hold a single knowledge system, acting knowledgeably is often unproblematic and relatively easy compared to the challenges of operating within CoIs, which often do not share a common language and practice. Various social strategies have been proposed to mitigate these challenges and facilitate the sharing of knowledge and allowing knowledgeable performances within CoIs, such as: developing *boundary objects* (Bowker and Star, 2000), supporting *knowledge brokers* (Barbara and Clifton, 1992), fomenting the use of electronic communication systems, and disseminating "useful-practices" (in contrast to best-practices) (Orlinkowski, 2002). These strategies are important as attempts to circum-

vent the social and technical obstacles that often impede an effective exchange of information within CoIs.

Distributed Cognition

The *design perspective* requires a framework for studying the distributed nature of KM. Resting on a distributed and coordinated notion of knowledge, such a framework should account for the complex, distributed, and sociohistorical nature of human actions in the world. In our research, we have employed distributed cognition (Hollan, et al., 2001, Salomon, 1993) as such a framework.

Distributed cognition holds that knowledge does not necessarily reside solely in a person's head, but is often created by and revealed in social practices, and mediated by sociotechnical artifacts situated in a social environment. One major contribution of this framework is to expand the unit of analysis for cognition from merely focusing on cognitive processes in an individual's head toward a systemic view of cognition delimited by functional relationships of the elements that participate in a task situated in a sociohistorical context. Another important contribution is to bring culture, context, and history back to the study of cognition. According to distributed cognition, all human activities are embedded in sociohistorical contexts, which are not solely created by local cultural and historical practices, but also co-created by each participant's own history and life-experience.

Social Networks

Social networks (SNs) offer a way to understand the complex dynamics of communities (Hillary, 1955), and how people exchange support, by shifting away from a sociogeographic structure toward a structure of interpersonal relationships (Wellman and Gulia, 1999). SNs help us understand how individuals share information, experiences, and support, and how they accomplish their tasks (Nardi, et al., 2000). Sns are source of human capital (Coleman, 1988) that allow stakeholders to engage in socially meaningful collaborative activities, helping them recognize the importance of their cohort in the building of knowledge. The strength of interpersonal ties (weak or strong) is instrumental to community organization, the diffusion of influence, information and innovation, social cohesion, and emotional and professional support (Granovetter, 1973, Rogers, 1995).

The SN view of exclusively linking people needs to be extended to include information, resources, and artifacts. A knowledge level perspective

is required to extend the traditional view of an SN (Carley and Hill, 2001). Traditionally, an SN refers to "the who" in the organization, which refers to the active agents who possess the knowledge to get the work done. "The who" is capable of knowing some of "the what" or "who else to ask," and thereby capable of taking knowledgeable actions. "The what" is essentially information (i.e., resources, personal and professional support, and related personal experiences and stories) that is traditionally not an element of an SN. From the *design perspective* of KM there is a need to integrate "the who" and "the what," and, more important, to support the synergy between them so as to allow knowledge to be enacted in practice. SNs in organizations thus become distributed cognition systems, the existence of which can be often attributed to balanced information ecologies.

Information Ecologies

The distribution of cognition in an SN creates the need for the orchestration of human actions to allow common goals to be achieved. Such orchestrated actions, as Hutchins describes in his account of ship navigation (Hutchins, 1993), can be achieved only through learning-by-doing-in-practice and, more important, through learning to become an active and responsible member of a CoP or CoI. The last construct of our framework concerns the nature of the relationships among all elements that participate in creating the contexts in which knowledgeable actors knowledgeably act. Its major focus is not on the synthesis of such elements, but on their synergy. Ecology can be thought of as a cognitive architecture—complex networks of stakeholders interacting, and thereby enabling information flow among them—and as a sociotechnical system.

The notion of ecology represents synergy among heterogeneous elements, and also alerts for the danger of ecological failure due to environmental imbalance (Nardi and O'Day, 1999). Ecology implies a focus on evolution, and the need to constantly nurture the relationships among its members. Hence, it should be given the time to grow, but not without its members' active efforts to direct and shape it so as to create adequate (social and technical) environments that in turn enable synergy among its elements. For instance, Nardi and O'Day (1999) describe the important, yet often unaccounted, work of librarians in corporate libraries. Librarians and clients often work together repeatedly and get to know each other. This allows librarians to better understand their clients' actual information needs, allowing them to offer information that their clients would otherwise be unable to find. Conversely, clients know when and how to appropriately place their requests by knowing what to expect from the librarians.

As sociotechnical systems, these *information ecologies* cannot be completely understood by the study of its parts, but by the relationships among them, that is, the complexity of integrating technology into the environment as well as its use and its reciprocal impact on the practices and the technology itself. Such interrelationships highlight the importance of active participation of those whose work practices and everyday lives will be affected by the technology, the long-term co-evolution of activities and technologies, and the "keystone species"—individuals with skills, experiences, and motivations without which an ecological system cannot adequately function.

Living Organizational Memories for KM

Based on the message of this chapter of that learning from the past is not enough, we need collaborative KM systems in which participants can go beyond the information given (Bruner, 1973) by creating new understandings and by learning from their peers. Informed participation (Brown, et al., 1994), which transcends the simple access to existing information sources (Fischer and Ostwald, 2002b), requires social changes as well as new interactive systems that provide the opportunity and resources for social debate and discussion rather than merely delivering predigested information to participants. Systems that attempt to capture "all possible information" are closed systems, and they are most likely to fail in supporting all needs from real-world problems without being constantly reinvented.

To change KM systems from closed to living organizational memories (Terveen, et al., 1995), we have developed a process model, *the seeding, evolutionary growth, and reseeding (SER) model* (Fischer, et al., 2001), that supports the design and deployment of evolving and sustainable systems. The SER model describes three phases of evolution in terms of the stakeholders involved and their activities. The *seeding* phase creates the initial conditions for the adoption and initial use of a system. The *evolutionary growth* phase is characterized by a series of "creation, integration, and dissemination" cycles (Fischer and Ostwald, 2001), whereby relevant information that emerges from work activities is created, integrated, and disseminated by those who own the problem. Finally, *reseeding* is a stage wherein the system is reorganized to address future needs.

The *SER* model is supported in turn by *meta-design*. *Meta-design* is a design approach that attempts to create technologies that support content changes as well as structural changes at *use time*. It supports processes for creating new media and environments that allow users to act as designers. It enables structural changes at technical, social, and content levels, and it

attempts to create a new mindset wherein users are no longer simply consumers of information, but are active co-designers (Fischer, 2002).

Web2gether: KM Support for Special Education

The Web2gether project is a multi-year-long effort embedded in the larger research project "CLever: Cognitive Levers – Helping People Help Themselves" (CLever, 2003) to understand and provide social and technical means for supporting the use of technologies in special education. Early in our investigation (Kintsch and DePaula, 2002), we found that one of the major barriers to the adequate use of technologies in this environment was the lack of professional as well as social support. We shifted then our approach from simply offering a technical solution to facilitate the access to these educational resources toward a sociotechnical approach to offer means for participants to reach each other, and thereby create and develop SNs. Web2gether was designed aiming at this goal by helping caregivers not only find resources, but form SNs and share their experiences. Sharing experiences has been shown to be an effective design approach for KM systems in the context of distributed and complex work practices (Bobrow and Whalen, 2002). It aims to go beyond the mere access model of technology (Arias, et al., 1999) by following the *SER* model. It is a collaborative KM system, which instantiates the conceptual framework presented in this chapter.

In our research, we were able to identify a series of conflicts and contradictions that emerged from special education practices, and opportunities to overcome some of these limitations with the support of the use of a collaborative KM system. The support for SNs is an important step toward the development of communities (of practice and interest). Our attempt to deploy and implement Web2gether in the schools has raised numerous concerns regarding its use and adoption. These concerns are presented here along with the lessons learned.

A Brief History of Web2gether

This project began when an assistive technology specialist from the BVSD created and distributed a CD-ROM with a large number of programs that were potentially beneficial for the education of students with special needs. The failure to see widespread use of the CD initiated our current research program and resulted in a conceptual framework for understanding the low

adoption and the high abandonment rates of technologies in special education (Kintsch and DePaula, 2002).

To address this problem, the CD-ROM was improved with *meta-data* to support the location of the available educational resources suited for particular needs. This extension was still limiting to the extent that it could not support the "creation-integration-dissemination" cycles (Fischer and Ostwald, 2001) that are necessary to support adequate sharing of information among and across social practices.

Table 2: Development Phases of Web2gether

	CD-ROM	Web2gether	
Development	Phase 1	Phase 2	Phase 3
Data Structures	Categories	Meta-data	Personal experiences
Information Access	Browsing	Searching	Recommendation
Design Approach	Access	Access	Informed participation
Goal	Facilitate access to the resource by making them readily available	Facilitate the discovery of the resource by implementing searching mechanisms	Development of SN among caregivers to facilitate support to the use of technology in schools

We extended this approach by developing Web2gether. During the last few years, we have built a close relationship with the special education community, which has allowed us to collaborate on the design, development, and deployment of Web2gether. The information space of Web2gether was initially "seeded" with the software applications from the CD-ROM. This initial seed was considered to be a necessary condition to motivate users' active participation and thereby foster new contributions.

The system underwent three major design and development phases during this time. Table 2 shows the phases that have been implemented and assessed. It highlights the major design orientations in each phase, namely underlying data structures, major information access mechanisms, design approaches, and design goals. Aiming at providing support for the *design perspective* of KM and addressing some of the concerns from our

fieldwork, Web2gether evolved to becoming a *living organizational memory*. The design focused on the following considerations (see Fig. 1 for more details on the implementation of this considerations):

- Ongoing support for the professional development process;
- Equal access to the professional development opportunities;
- Safe environment for sharing experiences and ideas in that participants have their privacy and confidentiality assured;
- Recognition and reward mechanisms for achievement and participation;
- Support for both institutional as well as individual requirements (i.e., a resource shared through the technology should address the particular needs of a student with disabilities and his or her particular educational goals based on the curriculum);
- Help for users to find others with similar interests, needs, and experiences, and to effectively enable them to find information/resources relevant to the task at hand;
- Support for managing personal contact in order to facilitate communication and overcome the sense of isolation.

Web2gether allows users to share stories and personal experiences (Denning, 2001, Thomas, 2001) regarding unique cases in which users came up with effective solutions to address their unique needs. For example, In the *Café* (see Fig. 1) users may share experiences regarding unique behavior challenges in trying to facilitate inclusion of students in the general education classrooms; adaptations made on existing technologies for unusual situations not anticipated by technology designers (e.g., computer games originally designed for entertainment being utilized to help a student with severe cognitive disability to learn cause-and-effect concepts); and accommodations and modifications of curricular materials to meet the unique needs of students with multiple disabilities (see Area 5 in Fig. 1).

By making the accumulated experiences of individuals in an organization publicly available to each other, and in particular to newcomers, we hypothesized that Web2gether can help in establishing connections among weakly bonded individuals (see Area 1, 2, and 6 in Fig. 1). Information sharing thereby facilitates the development of stronger social bonds among like-minded individuals facing similar experiences, thereby enabling the exchange of professional and personal support. Web2gether can enhance the practices in special education by helping these professionals connect with one another and get the support they need to cope with their day-to-day challenges (see Area 1 in Fig. 1).

The goal of Web2gether was not only to enable users to access information relevant to their problems at hand, but also to turn these resources into

Fig. 1. Web2gether Screenshot – This figure highlights six major areas of the Web2gether system that address some of the design consideration presented in this chapter: 1) Management of personal contact information; 2) Support for finding resources relevant to the problem at hand (Similar Contents); 3) Collaboration and professional support (Users' Comments); 4) User's relationship with the contributor; 5) Support for institutional requirements and individual needs; and 6) Who is accessing?– social awareness based on social networks.

objects-to-think-with as well as *objects-to-talk-about* (i.e., to provide means whereby users can interactively rethink their problems, re-conceptualize information needs, and share their problems and ideas). For

instance, in reading others' personal experiences and stories, a user could learn how to approach a given problem and identify unique modifications in existing technologies to support it. Web2gether makes use of stories as means for fostering the creation and dissemination of personal experiences by continuous learning to replenish and renew the existing stock of life-experiences and educational resources. These experiences not only provide situated information regarding the context in which the technology and education materials were previously utilized, but also provide means for users to identify other users with similar experiences to ask for support. By doing so, they become means for the creation and development of an SN among those involved with special education.

Research Setting and Methods

The design, development, use, and assessment of Web2gether took place at various schools in the Boulder Valley School District (BVSD)—a school districted in Colorado, in which our research center is located. In the BVSD, special education services are available to all students whose disabilities interfere with their ability to receive reasonable benefit from general education instruction alone. Currently, the district offers special education support to more than 3400 students, ranging from students with mild learning or emotional disabilities to students with severe multiple disabilities. Approximately 165 special education teachers, 300 teacher aides, 15 occupational and physical therapists, and 30 speech language pathologists work with these students.

We collected data through participant observation, semi-structured interviews, and informal open-ended interviews. We conducted a series of site-visits at different schools in the BVSD, where we observed and followed the work of special education professionals, and we carried out a series of semi-structured and informal interviews with special education teachers and related service providers, namely occupational and physical therapists, speech language pathologists, social workers, and psychologists, to understand the issues pertaining to the use of technologies in the support of their students. We observed the work of several of these professionals working directly with students with disabilities, and participated in a few technology-training meetings.

Lessons Learned

Table 3 summarizes the lessons learned from our research. It highlights the major opportunities as well as challenges to the use of Web2gether by special education professionals in schools. Our fieldwork has revealed a great opportunity to apply the *design perspective* to support special education information and support needs. In contrast to the traditional views of education and classrooms, special education is a unique and complex work environment that involves not only the education of students with disabilities, but also continuous time, people, and resource management, not unlike a traditional office environment.

Opportunities for Web2gether

Special education teachers (hereinafter referred to as teachers) are frequently physically, professionally, and socially isolated from their peers and other professionals. Limited time for extra-curricular activities and the state of being constantly overworked (Barab, et al., 2001) contribute to the lack of opportunities for sharing and for building relationships with other professionals. They have been unable to establish connections that would facilitate the sharing of "know-how," information, and support important to their day-to-day challenges in dealing with the unique needs of their students, namely *universe-of-one*. Experiences to help other teachers cope with emerging problems are seldom shared. Teachers often find themselves unable to deal with issues that peers may have already experienced and for which they found solutions. Not knowing "who to ask, and who to tell" (Kass and Stadnyk, 1992, Nardi, et al., 2000) becomes a major problem in coping with the *universe-of-one* nature of special education. *Learning from the past* is unable to fully address these issues. One example is the traditional teacher professional development method that hinges on training programs and the development of best practices or training is inadequate to provide the ongoing and long-lasting support necessary for a sustainable education of these professionals (Barab, et al., 2001, Schlager, et al., 2002). Being isolated and having to deal with very unique problems are great challenges in special education work practices, but they also offer great opportunities to the use of Web2gether.

Table 3: The Opportunities and Challenges to the Use of Web2gether

	Opportunities	Challenges
Nature of Knowledge	Universe-of-one	Highly situated in time and students' day-to-day needs
Creation	Teachers dealing with unique cases, create situated solutions to these problem	Time constraints, and motivating active participation
Integration	Matching solutions of unique cases with the problem at hand, and matching unique uses of technologies with the curriculum	Time and knowledge for doing the matches
Tasks	Find resources and support from others to help educate their students	Constant management of resources, and paperwork – impediments to the use of innovation
Learning	From each other's experiences and stories	Costs of actively participating and taking the time to learn
Dissemination	Reducing the costs by connecting individuals facing similar experiences	Time constraints, privacy, and lack of a culture of sharing
Technologies	Living OM and recommender system	Costs of learning to use innovations, acceptance of innovations and changes
Work Style	Constant needs for adaptations and modifications to match the educational needs and abilities of students – highly improvised	Overworked, and under constant time pressure
Social Structures	Overcoming the physical isolation or classroom limitations and constraints	Top-down (or institutionalized), lack of a sharing culture, and isolated
Work Structures	Reaching those facing similar challenges	Hierarchical, highly regulated
Incentive Structures	Personal initiatives	Difficulties to motivate risk-taking or learning
Breakdowns	Learning from experience, and improving existing practices	Lack of resources and time to cope with the costs of failures

Benefiting from Existing Information Ecologies. Special education is a complex environment in which one finds a few cohesive information ecologies. Within these ecologies, information, support, activities, and technologies necessary for the adequate support of the needs of students with disabilities synergistically flow among special education professionals and through their artifacts and social practices. They are, however, the exception rather than the rule—islands of success stories made possible by the dedication and hard work of individual persons. We saw an opportunity in Web2gether to provide a means whereby teachers can bridge these ecologies, find the professional and personal support they need, and share their experiences.

Important *key species* in these ecologies are the assistive technology specialists. They play a critical role in fostering the use of technology and the dissemination of information across schools. The use of technologies hinges on the active involvement and ability of these professionals not only to find the appropriate technologies, but also to collaborate with teachers and parents in accommodating, modifying, and learning how to use them. These specialists act as "knowledge brokers," bridging the gap between those who need support and the potential solutions. In realizing the role played by these professionals, a great deal of design effort was put on supporting their work. Not only are they likely to benefit the most from a broader adoption of Web2gether, but they experience a lower entrance cost (or threshold) to use it because their practices are more closely related to the use of such technology from the beginning. There is a higher value in using the system as well as motivating others to use it. In this regard, they play a critical role in disseminating the use of the system throughout the district because one important aspect of their work is to provide these professionals with new technologies.

Learning by Sharing Experiences. The exchange of stories is an important aspect of learning among special education professionals. They often share stories and life experiences as a means to give and receive technical, professional, and social support. Stories set the stage for discussions as well as create the necessary common ground for helping and learning to take place. They help these professionals learn from each other and understand the context in which solutions to the problems are employed so they can attempt to carry them over to their specific situations and needs. We observed in our fieldwork that stories provide more situated and contextual information regarding the experience, allowing specialists to contrast the current situation with their previous experiences, and thereby come up with more effective solutions to the problem at hand. This

is often the case among collocated professionals or those working in teams within schools, but it is seldom the reality across schools. The only opportunities take place in training sessions or in-services offered by the district. Web2gether attempts to help teachers overcome these physical barriers, allowing them to reach out to one another and exchange their experiences.

Much of the reality concerning the actual use of Web2gether was unveiled when we attempted to introduce it into the work practices. This has helped us further understand the barriers for change in the school environment, which hinders attempts to introduce Web2gether into its practices. We observed that these barriers for change became a major impediment in the adoption of the system. Not being able to change existing practices and norms directly affected the use and adoption of the system. We next describe some of these barriers when we introduced Web2gether into special education work environments. They highlight the major challenges special education professionals face in using the system to support their work practices (see Table 3).

Barriers for Change: Challenges in Introducing Web2gether

> *"This book is not so much about stories to preserve organizations: it's about using stories to change them." (Denning, 2001, p xviii)*

Technological innovation is only one side of the solution for the challenges teachers face in their daily practices. For Web2gether to add any value to their practices, it needs to be meaningfully integrated into the overall organizational structures (i.e., social, work, and incentive structures). This requires changes in both technology and organization.

Changes are often subject to conflicts and resistances. The complex interrelation between technical and organizational changes is seldom reported in the KM literature. In our research, despite all the efforts to seed the information spaces with appropriate contents and despite the support from the department of special education in the district to facilitate the introduction of Web2gether into the classrooms, we faced many challenges to overcome the barriers to organizational changes.

Lack of Incentive Structures. The school system offers little incentive for promoting changes, taking risks, and adopting innovative ideas. The only reward for changing and trying to improve the education of their students is the teachers' personal satisfaction and the sense of self-fulfillment. Schools often do not reward their employees for achievements, but are

likely to punish them for failures (Hodas, 1996). Teachers rarely take risks in implementing innovations whose benefits are not directly associated with the institutional interests.

Lack of Time. Time pressure often hinders any attempt or willingness to find, learn, and use new technologies. Due to ongoing time pressures, teachers are more likely to see high costs in the use of a technology. They then face the dilemma of the active user (Carroll and Rosson, 1987): how to balance time to get the work done and to learn to use an innovation. The dilemma of the active user is related to the rational choices workers make while facing competing or conflicting situations, such as the trade-offs between dealing with pressing problems and investing in long-term solutions (such as learning to use a new technology). Overcoming this situation does not necessarily reside on learning outweighing work, or vice versa, but rather on the integration of both. Learning and working should become the same aspect of carrying out any activity in a work practice. Toward this end, innovations in the workplace have to be meaningfully integrated into practices, so that learning and use become the same activity through which users can see tangible benefits and long-term impact in their work practices and careers.

Tangible Rewards and Long-term Investments. In normal situations, special education professionals are likely to take a more conservative position and carry out activities that are likely to have a clear and short-term impact on their work as well as their careers. For example, special education teachers are likely to spend a great deal of their time teaching their students to take the standardized tests because these tests have a direct and obvious impact on their work, as opposed to spending time engaging in activities to learn how to use Web2gether so that they can obtain support from other professionals. In this kind of situation, institutional pressures that clearly impact their careers eclipse any benefit from the long-term investments of using Web2gether.

Merging Existing with New Structures. In order to understand the challenges to change is critical to first understand the relationship between social and technical structures existing in the environment and the social and technical structures embedded in the design of a technology. The introduction of a technology often requires institutional and social changes to accommodate the new structures engendered in its use. If these new structures conflict with the existing ones in some respects, a barrier to change will ensue, and innovations likely will not be adopted. The reconciliation of these two structures can be facilitated by the use of participatory design activities as well as *meta-design* approaches to allow users to make appropriate modifications and accommodations in the structures em-

bedded in the technology as the need for changes unfold through its design and use.

"Build It and No One Comes:" Challenges in the Seeding Process

One major challenge in the design and deployment of Web2gether was that "*we build it, and no one came*" (Smith and Farquhar, 2000). Collaborative and evolving systems are of no value or use without users' active and informed participation and contributions. To help overcome this "cold-start" problem, the information space on Web2gether was initially seeded (Fischer, et al., 2001) with the software applications from the CD. We hypothesized that this initial seed was argued to be a necessary condition to motivate teachers' active participation and thereby foster new contributions.

Despite the seeding process, no major use of Web2gether was observed early in the project. Ever during the design of Web2gether, we were not convinced that "if we build it, they would come."

Creating meaningful seeds is the first step toward this goal. The seed was originally regarded to be the technical infrastructures and the initial contents implemented on Web2gether. This notion had to be extended to include social infrastructures to support the use of the system in its users' everyday work activities. We concluded that a meaningful seed for a KM system necessarily has to address the existing information and support needs, but it should not be limited to technical functionalities and content. In our research it was fundamental to provide social infrastructures that permit users to integrate the innovations and changes promoted by the use the system into their everyday work practices.

A seed should be a bridge between existing practices (and the sociotechnical structures embedded in them) and the innovations (and the sociotechnical structures embedded in the design of the system):

- It should provide social structures that promote collaboration and connections between users;
- It should set the tone of the discussions and interactions to help them understand the possibilities offered by the system; and
- It should also be built on structured activities that help integrate the use of the system and their everyday activities, thereby facilitating its adoption.

A seed is a *boundary object* that, while helping users make sense of the sociotechnical system by linking innovation and existing practices, creates opportunities for them to rethink and improve these practices in this new

context. It is the first step to facilitate a meaningful integration between "traditions and transcendences."

From *Knowledge of the Past* to *Informed Participation*

The "knowledge of the past" approach for the design of KM systems reinforces a passive notion of information sharing, in which users are supposed to act as consumers of information previously digested by content designers or knowledge engineers. It encourages forms of participation that are primarily motivated by an individual's interest in self-benefit ("what is there for me now?"), which is generally not conducive to a more sustainable participation, and thereby to the development of a living organizational memory. In contrast, the *design perspective* puts forth the notion of "knowledge as enacted in practice," emphasizing that knowledge is constantly evolving as a by-product of "knowers'" interactions with one another and acting in the context of their social practices. Knowledge requirements and workers' participations are not static—everyone is a potential knowledgeable contributor.

It is critical that users abandon a purely "consumer" mindset, and take on a more *designer mindset* (Fischer, 2002). This is a cultural change whereby users learn to take an active as well as informed role in the processes that directly impact their own work practices and social environments. Moving from the mere passive attitude of expecting to be able to access all possible resources toward a more active attitude of becoming informed participants represents a major cultural shift not only in the ways people make use of collaborative KM systems, but in the ways they do their work, interact with others, and see their roles in the society. It does not mean that users need to be active all the time, but to be willing to take risks, learn, and do things in ways that have not been imagined before in order to contribute to their personal development as well as the development of their social practices, and helping them to do the same. Only with this progressive attitude can collaborative KM systems such as Web2gether be of value to its users and to society in general.

Conclusion

In this chapter, we have proposed the *design perspective* of KM. It supports the concept of social networks in which communities of practices and interests work collaboratively produce solutions to complex design prob-

lems. Knowledge is viewed as distributed and synergistically enacted by a network of actors when they carry out their design practices.

Special education is a complex environment that benefits from this KM perspective. Teachers face everyday unique challenges that require the expertise of a team of dedicated professionals working synergistically and collaboratively to help those with disabilities accomplish their daily tasks. In this environment, the *knowledge of the past* perspective is not enough. Instead, our fieldwork has shown the opportunities and benefits in introducing a KM system based on the *design perspective* into special education as a means for continuous learning. We have designed and implemented Web2gether to help special education professionals obtain ongoing and sustainable professional and personal support and to have access to education resources they need to help their students with disabilities.

These benefits are not likely to be realized without the co-evolution of practices and technology. Technology alone will not solve the institutional and cultural challenges necessary for the implementation of the *design perspective* on KM. Major institutional and technical barriers for change need to be overcome. Changes will take place only if those involved in the design and development of innovations come to appreciate the delicate balance between existing cultural practices and innovations. Without a seamless integration of these two "worlds," we will not be able to create the necessary sociotechnical conditions for a new synergy between existing structures and new structures to emerge. Only through a careful balance between "tradition and the transcendence" will KM solutions be able to augment existing norms, values, and cultures with innovations.

Our research in this context supports the argument why *learning from the past is not enough* to help stakeholders accomplish their tasks practices. Knowledge is not a commodity to be consumed but is collaboratively designed and constructed in the *doing of work*. Our fieldwork has unveiled the opportunities as well as the challenges of implementing an alternative perspective for KM, *the design perspective*, which addresses this complex and situated nature of work. A complete discussion on KM cannot be limited to an epistemological analysis of knowledge or a technical evaluation of KM systems. It has to address the social, political, and technical issues of existing practices to guide the design as well as the introduction of KM innovations into the practices of those will be directly affected by them.

Acknowledgments

The authors thank the members of the Center for LifeLong Learning & Design (L^3D) at the University of Colorado, in particular the members of the CLever Project funded by the Coleman Institute, who have made major contributions to the conceptual framework described in this chapter. The research was supported in part by (1) the *Coleman Institute*, University of Colorado at Boulder; (2) the *National Science Foundation*, Grants (a) REC-0106976 "Social Creativity and Meta-Design in Lifelong Learning Communities," and (b) CCR-0204277 "A Social-Technical Approach to the Evolutionary Construction of Reusable Software Component Repositories"; and (3) *SRA Key Technology Laborato*ry, Inc., Tokyo, Japan.

References

Arias, E. G., Eden, H., Fischer, G., Gorman, A. and Scharff, E. (1999). *Beyond Access: Informed Participation and Empowerment*. In C. Hoadley (Ed.), Proceedings of the Computer Supported Collaborative Learning (CSCL '99) Conference, Stanford, pp. 20-32.

Barab, S. A., Makinster, J. G., Moore, J. A., Cunningham, D. J. and Team, T. I. D. (2001). Designing and Building an On-line Community: The Struggle to Support Sociability in the Inquiry Learning Forum. *Educational Technology Research & Development (ETR&D), 49* (4), pp. 71-96.

Barbara, D. and Clifton, C. (1992). I*nformation brokers: Sharing knowledge in a heterogeneous distributed system* (Techincal Report No. MITL-TR-31-92). Princeton, NJ: Matsushita Information Technology Laboratory.

Bobrow, D. G. and Whalen, J. (2002). Community Knowledge Sharing in Practice: The Eureka Story. *Journal of the Society for Organizational Learning, 4* (2).

Bowker, G. C. and Star, S. L. (2000). *Sorting Things Out — Classification and Its Consequences*. Cambridge, MA: MIT Press.

Brown, J. S. and Duguid, P. (1998). Organizing Knowledge. *California Management Review, 40* (3), pp. 90-111.

Brown, J. S. and Duguid, P. (2000). *The Social Life of Information*. Boston, MA: Harvard Business School Press.

Brown, J. S., Duguid, P. and Haviland, S. (1994). Toward Informed Participation: Six Scenarios in Search of Democracy in the Information Age. *The Aspen Institute Quarterly, 6* (4), pp. 49-73.

Bruner, J. (1973). *Beyond the Information Given*. New York: W.W. Norton and Company.

Carley, K. M. and Hill, V. (2001). Structural Change and Learning within Organizations. In A. Lomi (Ed.), *Dynamics of Organizational Societies: Models, Theories and Methods*. Cambridge, MA: MIT Press/AAAI Press/Live Oak.

Carroll, J. M. and Rosson, M. B. (1987). Paradox of the Active User. In J. M. Carroll (Ed.), *Interfacing Thought: Cognitive Aspects of Human-Computer Interaction*. Cambridge, MA: The MIT Press, pp. 80-111.

CLever. (2003). *CLever: Cognitive Levers -- Helping People Help Themselves*, at http://www.cs.colorado.edu/~l3d/clever

Coleman, J. S. (1988). Social Capital in the Creation of Human Capital. *American Journal of Sociology, 94*, pp. S95-S120.

Denning, S. (2001). *The Springboard: How Storytelling Ignites Action in Knowledge-Era Organizations*. Woburn, MA: Butterworth-Heinemann.

Ehn, P. (1988). *Work-Oriented Design of Computer Artifacts* (second ed.). Stockholm: Arbetslivscentrum.

Engeström, Y. (2001). Expansive Learning at Work: Toward an Activity Theoretical Reconceptualization. *Journal of Education and Work, 14* (1), pp. 133-156.

Fischer, G. (1994). Putting the Owners of Problems in Charge with Domain-Oriented Design Environments. In D. Gilmore, R. Winder and F. Detienne (Eds.), *User-Centered Requirements for Software Engineering Environments*. Heidelberg: Springer Verlag, pp. 297-306.

Fischer, G. (2001). *Communities of Interest: Learning through the Interaction of Multiple Knowledge Systems*. In S. Bjornestad, R. Moe, A. Morch and A. Opdahl (Ed.), 24th Annual Information Systems Research Seminar In Scandinavia (IRIS'24), Ulvik, Norway, pp. 1-14.

Fischer, G. (2002). Beyond 'Couch Potatoes': From Consumers to Designers and Active Contributors. *FirstMonday: Peer-Reviewed Journal on the Internet, 7* (12), at http://firstmonday.org/issues/issue7_12/fischer/.

Fischer, G., Grudin, J., McCall, R., Ostwald, J., Redmiles, D., Reeves, B. and Shipman, F. (2001). Seeding, Evolutionary Growth and Reseeding: The Incremental Development of Collaborative Design Environments. In G. M. Olson, T. W. Malone and J. B. Smith (Eds.), *Coordination Theory and Collaboration Technology*. Mahwah, NJ: Lawrence Erlbaum Associates, pp. 447-472.

Fischer, G. and Ostwald, J. (2001). Knowledge Management — Problems, Promises, Realities, and Challenges. *IEEE Intelligent Systems, January/February 2001*, pp. 60-72.

Fischer, G. and Ostwald, J. (2002a). *Seeding, Evolutionary Growth, and Reseeding: Enriching Participatory Design with Informed Participation*. In T. Binder, J. Gregory and I. Wagner (Ed.), Proceedings of the Participatory Design Conference (PDC'02), Malmö University, Sweden, pp. 135-143.

Fischer, G. and Ostwald, J. (2002b). *Transcending the Information Given: Designing Learning Environments for Informed Participation*. In e. a. Kinshuk (Ed.), Proceedings of International Conference on Computers in Education (ICCE 2002), Auckland, New Zealand, pp. 378-381.

Fischer, G. and Scharff, E. (2000). *Meta-Design—Design for Designers*. In D. Boyarski and W. Kellogg (Ed.), 3rd International Conference on Designing Interactive Systems (DIS 2000), New York, pp. 396-405.

Granovetter, M. (1973). The Strength of Weak Ties. *American Journal of Sociology, 78*, pp. 1360-1380.

Grudin, J. (1988). Why CSCW Applications Fail: Problems in the Design and Evaluation of Organizational Interfaces. In L. Suchman (Ed.), *Proceedings of ACM CSCW'88 Conference on Computer-Supported Cooperative Work*. New York: ACM, pp. 85-93.

Hansen, M. T. (2002). Knowledge Networks: Explaining Effective Knowledge Sharing in Multiunit Companies. *Organization Science, 13* (3), pp. 232-248.

Hillary, G. A. (1955). Definitions of Community: Areas of Agreement. *Rural Society, 20*, pp. 111-1122.

Hodas, S. (1996). Technology Refusal and the Organizational Culture of Schools. In R. Kling (Ed.), *Computerization and Controversy: Value Conflicts and Social Choices* (Second ed., Vol.). San Diego, CA: Academic Press, Inc.

Hollan, J., Hutchins, E. and Kirsch, D. (2001). Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research. In J. M. Carroll (Ed.), *Human-Computer Interaction in the New Millennium*. New York: ACM Press, pp. 75-94.

Hutchins, E. L. (1993). Learning to Navigate. In S. Chaiklin and J. Lave (Eds.), *Understanding Practice*. Cambridge, UK: Cambridge University Press, pp. 35-63.

Kass, R. and Stadnyk, I. (1992). Using User Models to Improve Organizational Communication. In *Proceedings of 3rd International Workshop on User Modeling (UM'92)*. Dagstuhl, Germany: The German Research Center for Artificial Intelligence, pp. 135-147.

Kintsch, A. and DePaula, R. (2002). *A Framework for the Adoption and Abandonment of Assistive Technology*. In (Ed.), SWAAACK Conference, Breckenridge, CO.

Lave, J. and Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. New York: Cambridge University Press.

Murray, P. (2000). Designing Busineess Benefits from Knowledge Management. In C. Despres and D. Chauvel (Eds.), *Knowledge Horizons: The Present and the Promise of Knowledge Management*. Boston, MA: Butterworth-Heinemann, pp. 171-194.

Nardi, B. A. and O'Day, V. L. (1999). *Information Ecologies: Using Technology with Heart* (First ed.). Cambridge, Massachusetts: The MIT Press.

Nardi, B. A., Whittaker, S. and Schwarz, H. (2000). It's Not What You Know, It's Who You Know: Work in the Information Age. *FirstMonday: Peer-reviewed Journal on the Internet, 5* (5), at http://www.firstmonday.dk/issues/issue5_5/nardi/.

Orlinkowski, W. J. (2002). Knowing in Practice: Entacting a Collective Capability in Distributed Organizing. *Organization Science, 13* (3), pp. 249-273.

Orr, J. (1990). Sharing Knowledge, Celebrating Identity: War Stories and Community Memory in a Service Culture. In D. S. Middleton and D. Edwards

(Eds.), *Collective Remembering: Memory in Society*. Beverly Hills, CA: SAGE Publications, pp. 169-189.

Orr, J. (1996). *Talking about Machines — An Ethnography of a Modern Job*. Ithaca: ILR Press/Cornell University Press.

Polanyi, M. (1966). *The Tacit Dimension*. Garden City, NY: Doubleday.

Postman, N. (1995). *The End of Education — Redefining the Value of School*. New York: Alfred A. Knopf.

Rittel, H. (1984). Second-Generation Design Methods. In N. Cross (Ed.), *Developments in Design Methodology*. New York: John Wiley & Sons, pp. 317-327.

Rogers, E. M. (1995). *Diffusion of Innovations* (Fourth ed.). New York, NY: The Free Press of Glencoe.

Salomon, G. (Ed.). (1993). *Distributed Cognitions: Psychological and Educational Considerations*. Cambridge, United Kingdom: Cambridge University Press.

Schlager, M. S., Fusco, F. and Schank, P. (2002). Evolution of an On-line Education Community of Practices. In K. A. Renninger and W. Shumar (Eds.), *Building Virtual Communities: Learning and Change in Cyberspace*. Cambridge, MA: Cambridge University Press, pp. 129-158.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books.

Smith, R. G. and Farquhar, A. (2000). The Road Ahead for Knowledge Management — An AI Perspective. *AI Magazine, 21* (4), pp. 17-40.

Snowden, D. J. (1998). The Paradox of Story: Simplicity and Complexity in Strategy. *The Journal of Strategy & Scenario Planning* (Nov 1998), pp. 1-8.

Spender, J. C. (1996). Making Knowledge the Basis of a Dynamic Theory of the Firm. *Strategic Management Journal, 17* (Winter Special Issue), pp. 45-62.

Terveen, L. G., Selfridge, P. G. and Long, M. D. (1995). Living Design Memory: Framework, Implementation, Lessons Learned. *Human-Computer Interaction, 10* (1), pp. 1-37.

Thomas, J. (2001). *Information about Knowledge Management*, at http://www.truthtable.com/know.html

Tsoukas, H. (1996). The Firm as a Distributed Knowledge System: A Constructionist Approach. *Strategic Management Journal, 17* (Winter Special Issue), pp. 11-25.

Wellman, B. and Gulia, M. (1999). Net Surfers Don't Ride Alone: Virtual Community as Community. In B. Wellman (Ed.), *Networks in the Global Village*. Boulder, CO: Westview Press, pp. 331-367.

Wenger, E. (1998). *Communities of Practice — Learning, Meaning, and Identity*. Cambridge, UK: Cambridge University Press.