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The Structure of Organizational Knowledge

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Abstract: Structurally, organizational knowledge may be categorized into tacit, explicit, and cultural knowledge. Tacit knowledge is personal knowledge that is rooted in direct experience and revealed through skillful practice. Explicit knowledge is codified knowledge that has been written down, embodied in artifacts, or articulated in organizational rules and routines. Cultural knowledge consists of assumptions, beliefs, and values that are used to construct reality and to assign significance to new information and knowledge. Differentiating organizational knowledge in this way provides us with three sets of lenses to view the differences and dependencies between aspects of organizational knowledge. At the same time, understanding the structure of organizational knowledge poses some challenges for the design of organizational information systems.

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1. Introduction

If an organization is to manage its knowledge it needs to understand the structure of organizational knowledge and the dynamics that give this structure force and fluency. This paper suggests that it is helpful to analyze an organization's knowledge as consisting of three categories: tacit, explicit, and cultural knowledge. While the labels "tacit" and "explicit" are now common in the lingua franca of knowledge management, the concept of cultural knowledge has not received as much attention. We suggest that the effective use of knowledge in organizations engages all three categories of knowledge, and that cultural knowledge constitutes the interconnecting tissue that binds the exercise of tacit and explicit knowledge, by endowing knowledge work with value, purpose, and meaning.

Knowledge in organizations is not monolithic nor homogenous. For example, there is knowledge comprising of what the organization believes about itself (identity, purpose), its capabilities, and its environment (communities, markets). There is knowledge embedded in the physical goods the organization produces and in the rules and routines that the organization adopts. Again, every person in the organization also possesses personal knowledge that is derived from experience, skillful practice, and personal insight. For analytical and organizational design purposes, recent work by researchers, including Boisot (1998), Choo (1998), and Spender (1998), suggest that organizational knowledge may be divided into:

- (1) tacit knowledge,
- (2) explicit knowledge, and
- (3) cultural knowledge.

The main features of each category of knowledge are outlined in Table 2.1, and these will be elaborated as we examine each category more closely in the ensuing sections. For now we make a few observations about the interactions across these three forms of knowledge.

Table 1. Categories of Organizational Knowledge

Tacit Knowledge	The implicit knowledge used by organizational members to perform their work and to make sense of their worlds. Tacit knowledge is hard to verbalize because it is expressed through action-based skills and cannot be reduced to rules and recipes.
Explicit Knowledge	Knowledge that can be expressed formally using a system of symbols, and can therefore be easily communicated or diffused. Explicit knowledge may be object-based or rule-based.
Cultural Knowledge	The cognitive and affective structures that are habitually used to perceive, explain, evaluate, and construct reality. The assumptions and beliefs that are used to describe and explain reality, as well as the conventions and expectations that are used to assign value and significance to new information.

In many organizations, the effective utilization of knowledge typically involves all three forms of knowledge. Thus, a highly skilled designer, when applying her creative intuition (tacit knowledge), would work with tools, plans, and specifications (explicit knowledge), at the same time following the adopted values and norms of the profession or organization (cultural knowledge). The direction of interaction can work in the other way too, as when the result of work or actions based on tacit knowledge leads to the organization redefining and re-perceiving its roles and values. John Seely Brown of Xerox Corporation believes that the contribution of research is not just leveraging the tacit knowledge of its scientists, but also the invention of new cultural knowledge about the organization and its business:

The most important invention that will come out of the corporate research lab in the future is the corporation itself. As companies try to keep pace with increasingly unstable business environments, the research department has to do more than simply innovate new products. It must design the new technological and organisational ‘architecture’ that make possible a continuously innovating company. Put another way, corporate research must reinvent innovation ... [it] must prototype new mental models of the organisation and its business. (Brown 1991, p. 105)

At the organizational level, much of the discussion on core competencies and core capabilities implies a close integration of all three types of knowledge. Leonard (1995) for example, dimensionalizes organizational core capabilities into: employee knowledge and skill; physical and technical systems; managerial systems; and values and norms — dimensions that we recognize as manifestations of tacit, explicit and cultural knowledge. Core capabilities set the organization apart from the rest, and give it a competitive edge. Indeed, we may reason that the more closely coupled the three categories of

knowledge are in an organization, the more unique the advantage that the organization possesses, and the more difficult it is for others to copy that advantage.

2. Tacit Knowledge

Michael Polanyi examines human tacit knowledge by “starting from the fact that we can know more than we can tell” (1966, p. 4, italics in original). Tacit knowledge permeates our personal and work lives, enabling us to drive the automobile, enjoy a poem, or deal with a problem situation. In all such cases of personal knowing, “the aim of a skilful performance is achieved by the observance of a set of rules which are not known as such to the person following them” (Polanyi 1962, p. 49, italics in original). Tacit knowledge is hard to transfer or verbalize partly because it cannot be broken down into particular rules or elements, and partly because it exists as an emergent quality of knowing something as a whole.

Tacit knowledge may be likened to knowing that is in our action, “implicit in our patterns of actions and in our feel for the stuff with which we are dealing” (Schön 1983, p. 54). Schön defines this ‘knowing-in-action’ with the following properties:

- There are actions, recognitions, and judgments which we know how to carry out spontaneously; we do not have to think about them prior to or during their performance.
- We are often unaware of having learned to do these things; we simply find ourselves doing them.
- In some cases, we were once aware of the understandings which were subsequently internalized in our feeling for the stuff of action. In other cases, we may never have been aware of them. In both cases, however, we are usually unable to describe the knowing which our action reveals.
(Schön 1983, p. 54)

From her analysis of the work practices of operators in pulp and paper mills, Zuboff observed how operators relied on action-centered skills that are based on tacit knowledge:

When operators in Piney Wood and Tiger Creek discuss their traditional skills, they speak of knowing things by habit and association. They talk about ‘cause-and-effect’ knowledge and being able to see the things to which they must respond. They refer to

‘folk medicine’ and knowledge that you don’t even know you have until it is suddenly displayed in the ability to take a decisive action and make something work. (Zuboff 1988, p. 71, 187)

Tacit know-how is not limited to technical skills, but is just as important in undergirding the actions of professionals in architecture, engineering, management, psychotherapy, and so on (Schön 1983). Zuboff again provides an example of how bank account officers in the Global Bank Brazil made their credit decisions:

Our credit decisions have been more related to feeling than to technical skill. For big loans, the officer knows the client and the client’s environment. He spends time with that person. They dine together, play golf together. That is why we specialize by industry and company size. This is why the officer comes to know things that are not written. Credit is given by the feeling in one’s stomach.

(Quoted in Zuboff 1988, p. 164)

In organizations, tacit knowledge is the personal knowledge used by members to perform their work and to make sense of their worlds. It is learned through extended periods of experiencing and doing a task, during which the individual develops a feel for and a capacity to make intuitive judgements about the successful execution of the activity. Because tacit knowledge is action-centered and distributed in the totality of the individual’s action-experience, it cannot be isolated and packaged into elements or steps. Such interaction is situated in the social and physical setting where knowledge is engaged. Since tacit knowledge is experiential and contextualized, it cannot be easily codified, written down or reduced to rules and recipes.

Nelson and Winter (1982) suggest three reasons why knowledge used in an organization’s operations and practices is likely to be tacit to a significant degree: “because it cannot be articulated fast enough, because it is impossible to articulate all that is necessary to a successful performance, and because language cannot simultaneously serve to describe relationships and characterize the things related.” (p. 82) Speed of communication is a problem when the rate of information transfer is well below the rate needed to actually perform a task (such as serving a tennis ball). Articulation is a problem when the practical knowledge is limited in “causal depth”: that is, enough is known to perform a task without requiring deep theoretical understanding underlying that skill. Relating parts to the whole is a problem when efforts to exhaustively explain details lead to incoherent messages and information overload. The

relative significance of tacit knowledge is thus contingent on the situation surrounding its use: “The knowledge contained in the how-to-do-it book and its various supplements and analogues tends to be more adequate when the pace of the required performance is slow and pace variations are tolerable, where a standardized, controlled context for the performance is somehow assured, and where the performance as a whole is truly reducible to a set of simple parts that relate to one another only in very simple ways. To the extent that these conditions do not hold, the role of tacit knowledge in the performance may be expected to be large.” (Nelson and Winter 1982, p. 82)

2.1 Transferring Tacit Knowledge

Despite it being difficult to articulate, tacit knowledge can be and is regularly transferred and shared. Tacit knowledge can be learned through observation and imitation. Thus, apprentices learn their craft by following and copying their masters; professionals acquire expertise and norms through periods of internship; and new employees are immersed in on-the-job training. Professionals reflect on what they know during the practice itself (for example, when they encounter an unusual case) as well as afterwards (for example, in a postmortem), and in doing so test and refine their own tacit knowledge (Schön 1983). Tacit knowledge can also be shared. Although not completely expressible in words or symbols, tacit knowledge may be alluded to or revealed through rich modes of discourse that include the use of analogies, metaphors or models, and through the communal sharing of stories. Storytelling are effective channels of tacit learning because narratives dramatize and contextualize knowledge-rich episodes, allowing the listener to replay and relive as much of the original experience as possible.

Tacit knowledge is vital to organizations because it is an important source of new knowledge: new knowledge in the form of discoveries and innovations is often the outcome of creative individuals applying their tacit insights and intuitions to confront novel or difficult problems. The most advanced computer-based information systems on their own cannot generate new knowledge, only human beings who have accumulated expertise and experience have the capacity to do so.

Spender (1996, 1998) maintains that tacit knowledge as conceptualized by Polanyi (that “we can know more than we can tell”) is confusing because it bundles together two distinct properties of personal knowledge. Polanyi has suggested that tacit knowledge is both inaccessible to its possessor and incommunicable to another. For Spender (1998, p. 23),

“it is this confusion between the inaccessibility of the relevant knowledge to its possessor

and the ability of the possessor to convey that knowledge to another that renders this kind of explanation of tacit knowledge so unsatisfactory. We need to separate the internal communication or knowledge movement problem from the external interpersonal communication problem.”

In order to exclude the external communication dimension Spender proposes a narrowing of the tacit knowledge category to “implicit knowledge.” When people are solving problems, they often make use of implicit knowledge that they are not aware that they possess. This concept of implicit knowledge is supported by empirical evidence indicating that the human mind employs different methods and types of perceiving, remembering and learning, many of which lie outside the realm of mindful consciousness. Thus, Polanyi’s original observation that tacit knowledge exists because “we know more than we can tell” may be rephrased as implicit knowledge exists because “we know more than we know we know.” Spender further suggests that there are two kinds of implicit knowledge, one that is “individual and automatic,” and the other that is “social and collective” (Spender 1996, p. 60-64). “Individual-automatic knowledge” is acquired through extended practice, and its performance is characterised by apparent effortlessness. Such knowledge is often inaccessible at the conscious level. Thus, expert typists can seldom arrange key caps correctly even though they use the keyboard all day; experienced drivers simultaneously monitor several fields of secondary attention; and skilled musicians are focused on interpreting the work they are playing and are unaware of the mechanics of performance. “Social-collective knowledge” is knowledge that is an inherent property of the social system in which the individual participates. In organizations, people assimilate the collective norms and values of their groups and communities, and use these norms as taken-for-granted until occasions when for example they are faced with morally difficult choices that require them to reflect on underlying values. Such collective knowledge is part of organizational culture, and is often communicated through narrative forms of discourse. (We call this collective knowledge cultural knowledge in this paper.)

3. Explicit Knowledge

Explicit knowledge is knowledge that is expressed formally using a system of symbols, and can therefore be easily communicated or diffused (Nonaka and Takeuchi 1995). Explicit knowledge may be object-based or rule-based. Object-based knowledge may be found in artifacts such as products, patents, software code, computer databases, technical drawings, tools, prototypes, photographs, voice recordings, films, and so on. Knowledge is object-based when it is represented using strings of symbols (words, numbers, formulas), or is embodied in physical entities (equipment, models, substances). In the first case,

the symbols directly represent or codify the explicit knowledge. In the second case, explicit knowledge may be unpacked from the physical object by for example, reverse-engineering a product, inspecting software code, or analyzing the composition of a substance. One important distinction between tacit and explicit knowledge lies in the transferability of the knowledge, as well as the mechanisms that accomplish this transfer. Grant (1996a) suggests that “explicit knowledge is revealed by its communication. This ease of communication is its fundamental property.” (p. 111) On the other hand, tacit knowledge is revealed through its application. If tacit knowledge cannot be codified and can only be acquired through observation and practice, then its transfer between individuals is necessarily slow, costly, and uncertain (Kogut and Zander 1992).

3.1 Rule-based Explicit Knowledge

Explicit knowledge is rule-based when the knowledge is codified into rules, routines, or standard operating procedures. A substantial part of an organization’s operational knowledge about how to do things is contained in its rules, routines and standard procedures. Although all organizations operate with standard procedures, each organization would have developed its own repertoire of routines, based on its experience and the specific environment it functions in. Cyert and March (1963/1992) distinguish between four major types of rule-based procedures: task performance rules, rules for maintaining organizational records, information-handling rules, and planning rules. Task performance rules specify methods for accomplishing organizational tasks. They form the bulk of the organization’s rules and procedures and are important because they embody and facilitate the transfer of past learning. Performance rules also have a coordinating function, so that a solution implemented by one group is consistent with a large number of other solutions and tasks being performed elsewhere in the organization. Record keeping rules specify what records and how such records should be maintained by the organization. In the short term, records (such as financial statements or cost records) have a control effect. In the longer term, records are used to predict the environment by suggesting “simple hypotheses about the relation between the past and the future.” (Cyert and March 1963/1992, p. 126) Information-handling rules specify the organization’s communication system in terms of the characteristics of the information to be taken into the firm, the rules for distributing and summarizing internal and external information, and the characteristics of the information leaving the firm. Planning rules specify the periodic planning process as a standard procedure that produce intended allocation of resources among the activities of the organization. (Cyert and March 1963/1992)

Nelson and Winter (1982) suggest that organizational routines or rule-based knowledge play the role of

genes in an evolutionary theory of economic change which is based on three concepts:

The first is the idea of organizational routine. At any time, organizations have built into them a set of ways of doing things and ways of determining what to do. ... Second, we have used the term “search” to denote all those organizational activities which are associated with the evaluation of current routines and which may lead to their modification, to more drastic change, or to their replacement. ... Routines in general play the role of genes in our evolutionary theory. Search routines stochastically generate mutations. Third, the “selection environment” of an organization is the ensemble of considerations which affects its well-being and hence the extent to which it expands or contracts. The selection environment is determined partly by conditions outside the firms in the industry or sector being considered ... but also by the characteristics and behavior of the other firms in the sector.

(Nelson and Winter 1982, p. 400-401)

In this evolutionary perspective, organizations remember by doing, so that the routinization of activity in an organization constitutes the most important form of storage of the organization’s specific operational knowledge. Routines vary from well-specified technical routines for producing things; through procedures for hiring and firing, ordering inventory, or stepping up production; to policies on investment, R&D, or business strategies. As noted above, routines play the role that genes play in evolutionary biology. Routines as genes are persistent features of the organization that determine its range of possible behavior. They are inheritable in the sense that new “offspring” organizations (such as branch plants or regional offices) possess many of the features of their “parent” organization. They mutate as organizations make adjustments to their routines — sometimes by change, and sometimes as a response to external or internal change. They are selectable in the sense that organizations with certain routines may do better than others, depending on their fit with the environment.

3.2 Object-based Explicit Knowledge

An organization’s explicit knowledge may take the form of intellectual assets, which Sullivan (1998) defines as “the codified, tangible, or physical descriptions of specific knowledge to which the company can assert ownership rights. Any piece of knowledge that becomes defined, usually by being written down or entered into a computer, qualifies as an intellectual asset and can be protected. Intellectual assets are the source of innovations that the firm commercializes.” (p. 23) Examples of intellectual assets include plans, procedures, memos, sketches, drawings, blueprints, and computer programs.

Intellectual assets may be categorized into commercializable assets and structural assets (Sullivan 1998). Commercializable assets are those that the organization can directly offer in the business or technology marketplace (through for example, technology licensing or joint ventures). Commercializable assets may in turn be divided into those that are legally protected and those that are not. Legally protected assets are called intellectual property, and this includes for example, patents, copyrights, trademarks, trade secrets, and semiconductor masks. Unprotected assets that are nevertheless commercializable refer usually to the organization's innovations which are still undergoing development. Structural assets are part of the organization's infrastructure and may include its administrative and technical methods, processes, procedures, as well as role, authority and reporting structures. (In this paper, structural assets may be regarded as rule-based explicit knowledge.)

Explicit knowledge codified as intellectual assets are valuable to the organization because they add to the organization's observable and tradeable stocks of knowledge. Moreover, because they have been committed to media, ideas may be communicated more easily, increasing the likelihood of discussion, experimentation, and enhancement, thereby inducing further cycles of knowledge creation and use.

Explicit knowledge serves a number of important purposes in an organization. First, they encode past learning. Good solutions and procedures learned from experience are formalized as routines to avoid reinventing the wheel. Rules and routines can also be more easily packaged into training programs and tools that help transfer knowledge to new employees. Second, explicit knowledge facilitates coordination between disparate activities and functions in the organization. An organization's tasks are highly interdependent: plans, specifications, contracts, rules, and routines, are used to define outputs, standards, and timelines so that the interdependency of an organization's work activities can be properly coordinated. Third, explicit knowledge in the form of routines and procedures reduce the information processing load associated with task performance by stipulating premises, criteria, options, and other information seeking and use requirements. Fourth, the equipment, plans, budgets, and rules and routines that constitute explicit knowledge signify technical skill and procedural rationality, and so help the organization to present a self-image of competence, legitimacy and accountability.

4. Cultural Knowledge

While the classification of organizational knowledge as tacit and explicit is widely discussed, the category of cultural knowledge is less often encountered. Boisot (1998) attributes this to a "Western bias towards classifying as knowledge only that which can be given a codified and abstract formulation":

[This] has led knowledge assets — whether embodied in physical objects such as plant and machinery, or in organizational practices such as planning and budgeting systems — to be treated as if they were essentially technological in nature. They are not. They are first and foremost cultural and only then technological. The potential value of a knowledge asset is largely a function of how it is used and in what context. ... it does not make much sense to talk of knowledge assets independently of the cultures in which they are embedded. It takes culture as operating through institutional structures that must themselves be considered knowledge assets.

(Boisot 1998, p. 119, italics in original)

An organization's cultural knowledge thus consists of the beliefs it holds to be true and justifiably so (based on experience, observation, reflection) about itself and its environment. Importantly, an organization's cultural knowledge is used to answer questions such as "What kind of an organization are we?" "What knowledge would be valuable to the organization?" and "What knowledge would be worth pursuing?"

To elaborate, cultural knowledge in organizations consists of the cognitive and affective structures that are habitually used by organizational members to perceive, explain, evaluate, and construct reality. Cultural knowledge includes the assumptions and beliefs that are used to describe and explain reality, as well as the criteria and expectations that are used to assign value and significance to new information. These shared beliefs, norms and values form the framework in which organizational members construct reality, recognize the saliency of new information, and evaluate alternative interpretations and actions. Collins (1998) highlights two important roles of cultural knowledge: cultural knowledge is required to understand and use facts, rules, and heuristics; and to make inductions in the same way as others in order to enable concerted action. Cultural knowledge, by defining the limits and bases of legitimate discourse, also "constitutes the main conduit for the expression and existence of power, in the sense of defining what is legitimized as knowledge in the first place, and who are accorded sufficient reputation and status to have their views taken seriously in the second place." (Fleck 1998, p. 160) [Fleck's commentary echoes many others. For example, knowledge as power is a recurrent theme in much of Foucault's work (see for example Foucault 1977). Knowledge as paradigm received its most celebrated exposition in Kuhn (1970), who analyzed how normal science takes place within paradigms that define what kinds of problems are studied, what methods are acceptable, and what criteria are used to evaluation solutions.]

According to Sackmann (1991, 1992) cultural knowledge in an organization consists of: dictionary knowledge, directory knowledge, recipe knowledge, and axiomatic knowledge. Dictionary knowledge comprises commonly held descriptions, including expressions and definitions used in the organization to describe the 'what' of situations, such as what is considered to be a problem, or what is considered to be success. Directory knowledge refers to commonly held practices and is knowledge about sequences of events and their cause-effect relationships that describe the 'how' of processes, such as how a problem is solved or how success is to be achieved. Recipe knowledge comprises prescriptions for repair and improvement strategies that recommend what action 'should' be taken for example, to solve a problem or to become successful. Axiomatic knowledge refers to reasons and explanations of the final causes or a priori premises that are perceived to account for 'why' events happen. Sackman's categories of cultural knowledge are closely related to the schemas, scripts, cause maps, and basic assumptions that are often associated with discussions of organizational culture.

4.1 Technology as Cultural Knowledge

Garud and Rappa (1994) propose that the development of new knowledge based on technology is a socio-cognitive process which rests on three definitions of technology: "technology as beliefs, artifacts, and evaluation routines." (p. 345) Technology development is guided by beliefs about what is possible, what is worth attempting, and what levels of effort are required. Technology as physical artifact specifies the technology's form (such as shape or material of construction) and function (such as uses and applications). Technology as evaluation routines define testing routines and normative values that "filter data in a way that influences whether or not researchers perceive information as useful. Researchers with different beliefs attempt to sway each other with respect to the routines utilized to judge the technology." (Garud and Rappa 1994, p. 346) Evaluation routines also facilitate communication about the technology and allow the new technology to gain legitimacy in the eyes of researchers. Beliefs, artifacts, and evaluation routines interact with each other to shape the evolution of new technology. Garud and Rappa suggest that beliefs guide the creation of artifacts that in return raise commitment in the technology; beliefs are externalized as testing routines and standards; and routines legitimize and select the form that the technology takes. Overall, an organization's beliefs about what technology or new knowledge is feasible and worth attempting, a part of its cultural knowledge, would influence the direction and intensity of the knowledge development effort, as well as the routines and norms by which new information and knowledge would be evaluated.

In the context of knowledge creating, cultural knowledge plays the vital role of providing a pattern of

shared assumptions so that the organization can assign significance to new information and knowledge. Cultural knowledge supplies values and norms that:

determine what kinds of knowledge are sought and nurtured, what kinds of knowledge-building activities are tolerated and encouraged. There are systems of caste and status, rituals of behavior, and passionate beliefs associated with various kinds of technological knowledge that are as rigid and complex as those associated with religion. Therefore, values serve as knowledge-screening and -control mechanisms.

(Leonard-Barton 1995, p. 19)

There are familiar accounts of organizations in which cultural knowledge is misaligned with its efforts to exploit tacit and explicit knowledge. For example, Xerox PARC in the 1970s had pioneered many innovations that Xerox itself was not able to exploit but other companies later commercialized into products that defined the personal computer industry. Thus, PARC had invented or developed: bit-mapped display technology required for rendering graphical user interfaces; software for on-screen windows and windows management; the mouse as a pointing device; the first personal computer Alto; and an early word-processing software Bravo for the Alto (Smith and Alexander 1988). Xerox did not fully apprehend the application potential of these inventions because its identity and business strategy was still focused on the photocopier market. Many of the researchers working on these projects subsequently left PARC, taking their knowledge with them.

It is misleading to approach cultural knowledge as a form of background knowledge where the information is regarded as self-evident, so that the logical steps by which other forms of knowledge have to be justified are not required (Douglas 1975). It is tempting to view cultural knowledge as a stable, relatively static background before which new information and knowledge is perceived and engaged. Douglas (1975) warns that this “stability is an illusion, for a large part of discourse is dedicated to creating, revising, and obliquely affirming this implicit background, without ever directing explicit attention upon it.” (p. 4) Thus cultural knowledge is as dynamic as tacit and explicit knowledge in guiding and animating the use of organizational knowledge.

4.2 Cultural Knowledge in Knowledge Transfer

The movement of knowledge across organizational boundaries can involve tacit, explicit, and cultural knowledge to varying degrees. In a limited number of cases, the transfer is largely accomplished

through a movement of explicit knowledge (e.g. an equation, a chemical formula). Transfers of such well-defined packages of codified knowledge typically requires a substantial amount of collateral knowledge in the receiving organization to decode the new information (in-house engineers and technologies are needed to understand and apply the new equation or formula). In a larger number of cases, the transfer of explicit knowledge is accompanied and facilitated by experienced human experts. Experts interpret the meaning of the new information, and deal with the detailed questions arising from trying to use the new information. Thus, tacit knowledge is necessary to assimilate and apply new explicit knowledge properly. There are important cases when the movement of explicit knowledge even when accompanied by tacit knowledge is not enough: cultural knowledge is also necessary. This is especially so when organizations are trying to learn new practices or systems of work that are woven into organizational networks of roles, relationships, and shared meanings.

4.3 The Toyota Production System

Consider Toyota's production system, an example of a tight integration of tacit, explicit, and cultural knowledge:

Toyota's knowledge of how to make cars lies embedded in highly specialized social and organizational relationships that have evolved through decades of common effort. It rests in routines, information flows, ways of making decisions, shared attitudes and expectations, and specialized knowledge that Toyota managers, workers, suppliers and purchasing agents, and others have about different aspects of their business, about each other, and about how they can all work together.

(Badaracco 1991, p. 87)

When General Motors wanted to learn the Toyota production system, it established the NUMMI (New United Motor Manufacturing, Inc.) plant in 1984 as a joint venture with Toyota in order to facilitate the learning of 'intimate, embedded knowledge.' NUMMI took over a General Motors facility at Fremont California. Work at NUMMI was organized based on the Toyota's lean production system that seeks to utilize labor, materials, and facilities as efficiently as possible. The system is guided by the principles that quality should be assured in the production process itself with no defects overlooked or passed on, and that team members should be treated with consideration, respect, and as professionals ('full utilization of workers' abilities'). The NUMMI system combines employee involvement and continuous improvement processes. In order to ensure that each job is done in the most efficient way, the performance of the

work is specified explicitly by sequences or procedures. NUMMI team members themselves are responsible for setting the work standards, and continuously improving the job standards for maximum efficiency.

O'Reilly and Tushman (1997) observed that at NUMMI, the organizational culture includes norms about continuous improvement and team responsibility. Instead of feeling unmotivated, workers felt a sense of autonomy and responsibility. Instead of feeling monitored, workers "controlled" their own behaviors. In lieu of industrial engineers (there are none at NUMMI; the old GM Fremont plant had 82 industrial engineers), NUMMI workers are trained in industrial engineering techniques and the team itself undertakes work redesign and improvements:

... these methods and standards are determined by work teams themselves: workers are taught how to time their own jobs with a stopwatch, compare alternative procedures to determine the most efficient one, document the standard procedure to ensure that everyone can understand and implement it, and identify and propose improvements in that procedure. At any given time, the task of standardized work analysis might be delegated to a team leader or a team member, but everyone understands the analysis process and can participate in it.

(O'Reilly III & Tushman 1997, p. 90)

In a comparison of the Toyota-GM venture (NUMMI) and Volvo's Uddevalla plant, Adler and Cole (1993) noted that

... the Japanese production model explicitly focuses on strategies for organizational learning. Standardization of work methods is a precondition for achieving this end — you cannot identify the sources of problems in a process you have not standardized. Standardization captures best practices and facilitates the diffusion of improvement ideas throughout the organization — you cannot diffuse what you have not standardized. And standardization stimulates improvement — every worker is now something of an industrial engineer. At NUMMI, the skill development strategies for individual workers are managed as a component of this process, rather than as a way of maximizing personal opportunities. As a result, training focuses on developing deeper knowledge, not only of the relatively narrow jobs but also of the logic of the production system, statistical process control, and problem-solving processes.

(p. 92)

Although much has been published about Toyota's production system, without the NUMMI experience, GM might have permanently missed the essence of Toyota's management process. Co-practice to learn the system was necessary because the capabilities were "tacit know-how in action, embedded organizationally, systemic in interaction and cultivated through learning by doing" (Doz and Hamel 1997, p. 570). Badaracco (1991) concluded that through NUMMI, GM had the chance to learn first hand Toyota's collaborative approach to worker and supplier relationships, just-in-time inventory management, and efficient plant operations. For Toyota, the project helped it learn about managing US workers, suppliers and logistics, and about cooperating with the unions and the state and local governments. "Scores of GM managers and thousands of workers have worked at NUMMI or at least visited the operation. It would have been much simpler for GM to buy from Toyota the manual *How To Create the Toyota Production System*, but the document does not exist and, in a fundamental sense, could not be written. Much of what Toyota 'knows' resides in routines, company culture, and long-established working relationships in the Toyota Group." (Badaracco 1991, p. 100)

5. Summary

Structurally, organizational knowledge may be categorized into tacit, explicit, and cultural knowledge. Tacit knowledge is personal knowledge that is rooted in direct experience and revealed through skillful practice. Explicit knowledge is codified knowledge that has been written down, embodied in artifacts, or articulated in organizational rules and routines. Cultural knowledge consists of assumptions, beliefs, and values that are used to construct reality and to assign significance to new information and knowledge. Differentiating organizational knowledge in this way provides us with three sets of lenses to view the differences and dependencies between aspects of organizational knowledge. At the same time, understanding the structure of organizational knowledge poses some challenges for the design of organizational information systems:

Information systems have traditionally focused on explicit knowledge. How might we create more versatile systems with capabilities and functionalities to embrace tacit knowledge?

Cultural assumptions are implicit in the implementation of many information systems (e.g. the labels that are assigned to customers, events; the criteria that are used to evaluate cases, requests). How might we design flexible and transparent systems that allow these assumptions to be revised from time to time?

The organization that more tightly couples its tacit, explicit, and cultural knowledge would possess a more unique advantage. How may information systems be developed to increase the integrated use of these three forms of knowledge?

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