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■ *Research Paper*

Critical Systems Thinking as a Way to Manage Knowledge

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This paper is the first to introduce critical systems thinking into the present study of knowledge and its management. Our preliminary study showed two things about critical systems thinking. First, it provides comprehensive and creative insight into tackling the increasing complexity of human knowledge and knowledge management processes through the organic connection and division of knowledge systems. Second, it encourages the critical use of available methodologies in a coherent way to cope with corresponding subsystems or processes, which breaks down the complexity into convenient units. Based on critical systems thinking, we divided knowledge into two aspects: static substance knowledge and dynamic process knowledge. This division not only provides a concise theoretical framework but also allows knowledge managers and workers to clearly understand the gravity of their work and to selectively utilize well-established methodologies in the practice of knowledge-related activities. This paper serves as an introduction to an application of critical system thinking and total systems intervention in diversified human knowledge topics. Copyright © 2002 John Wiley & Sons, Ltd.

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In the modern world organizations are faced with innumerable and multifaceted issues which cannot be captured in the minds of a few experts and solved with the aid of some super-method. It would be equally wrong to revert to a trial and error approach. We need to retain rigorous and formalized thinking, while admitting the need for a range of problem solving methodologies.
Flood and Jackson, 1991.

INTRODUCTION

Knowledge has been recognized as one of the most important factors in economic growth. In view of its nature, characteristics and function, knowledge is totally different from other traditional production factors. The traditional approaches and ways of thinking about managing production factors have ceased to be effective in managing knowledge. Knowledge theories and practices, coming from different disciplines, make the term 'knowledge' rich and multifaceted but more complex. Thus, knowledge and

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knowledge management call for new insights in dealing with complexity.

This paper is the first to introduce influential critical systems thinking (CST) into knowledge and its management. With profound philosophical underpinnings, CST could shed light on the fundamental issues of knowledge, knowledge creation and management that intensively involve people with a variety of ideas in an ever-changing environment. CST perfectly enables researchers and practitioners to view knowledge and its management in organizations as a holistic system, seek for resolutions with the spirit of pluralism and critically leverage the well-established tools (methodologies, methods, models and techniques from various fields). Total systems intervention (TSI), as a system of systems methodologies, suggests employing these tools as a whole. In short, CST and TSI can offer knowledge managers and workers a theoretical framework for creative thinking and a useful practical methodological tool in managing knowledge systems and in addressing diverse interests during the activities.

CRITICAL SYSTEMS THINKING AND TOTAL SYSTEMS INTERVENTION

CST: A Philosophical Underpinning

CST, derived from social theory[1] and system thinking itself, was developed in the early 1980s (Jackson, 2001). At that time systems theorists reflected upon existing systems methodologies and their philosophies and created CST and TSI as a synthesis of these philosophies and methodologies. CST was 'propelled by an internal logic and by the responses it made to challenges from outside' (Jackson, 2000). Throughout the 1990s, the reflection of systems thinking, as an interactive process of theories and practices on the diversity of competing theories and the ever-changing social reality, required more tolerances on subjective observations and critical judgments on plural pragmatic approaches, which process could be considered as a starting point for research in the tangled knowledge field. The three theoretical commitments in CST are (1) critical awareness, (2) emancipation or improvement and (3) pluralism (Jackson, 2000).

Critical Awareness

Critical awareness encourages observing and thinking critically and consciously at both theoretical and practical levels. It requires exploring the research object and approach as well as background, for example, why the object was chosen as a research target, how the approach was developed, based on what hypotheses were discussed, and what their limitations, strengths and weaknesses were. Social awareness, as another aspect of critical awareness, requires actors not only to think directly about clients and other stakeholders, but also to pay attention to nature, community and society. It asks for giving full consideration to the social consequences of using different systems methodologies, decision-making and action. Critical awareness importantly affects the quality of work and working process while considering the interests of each stakeholder.

Human Emancipation

Emancipation is one of the three cognitive interests in Habermas's theory. CST sought philosophical support from the spirit of emancipation and embraced 'much broader dedication to human improvement' (Flood and Jackson, 1991) in circumstances for all individuals to realize their potential in their contributions to the whole human being and to improving their own conditions. Putting emancipation or local improvement on the agenda, critical system thinkers have to holistically consider humanity or the ethical and moral dimension. In dealing with methodology, it encourages the use of specifically emancipatory systems methodologies suitable for coercive contexts.

Pluralism

In the inception, complementarism at a theoretical level and complementarism at a methodo-

[1]Habermas's three basic human interests in acquiring knowledge and critical thoughts had a great influence on its philosophical underpinnings.

logical level were constitutive parts of CST. Afterward, the idea toward a coherent pluralism in system thinking was advocated by Jackson, interpreted in the broadest sense as the combinative use of different methodologies, methods and techniques in applied disciplines. First, it is the spirit of times that props up the use of methodologies adhering to different paradigms, and constantly encourages appreciating and respecting the diversity of theoretical findings. The complexity and dynamics of reality in the real world requires practitioners to improve their ability to tolerate wide-ranging opinions in their practices. Second, the richness in the methodological studies avails the combination of methodologies, methods, perspectives and approaches developed in separate disciplines based on variety of philosophies.

The nature of pluralism in critical system thinking, however, does not mean picking and mixing methodologies in a pragmatic way by compromising the idiosyncratic observations and principles. In problem contexts, system thinkers have to make active interventions in changing an operation while in process toward the desired direction with appropriate methodological backup and sensible combinations of methodologies. TSI was devised in the service of the end, although it also needs to be used by users critically in addressing specific problem situations (Jackson, 2000).

Once the variety of ways in intervening in and seeking for improving problem situations is fully appreciated, we agree that there does not exist one approach fit for all situations or one way of thinking to tackle everything; each has its strengths and weaknesses in addressing specific problems and issues in different contexts and with different aspects. The critical awareness incorporating social awareness reminds researchers of rethinking their research objects, ways of thinking, models, approaches and tools employed in a critical, reiterative and conscious way; complementarity among methodologies allows researchers to tackle multifaceted problems more effectively and efficiently and create their own toolkits in the way of system of systems methodologies.

TSI: A System of Systems Methodologies

TSI, developed by Flood and Jackson (1991), has critical systems thinking as its underpinning philosophy. The three phases in TSI were labelled creativity, choice and implementation (Jackson, 2000). In the creativity phase, the appreciations on different views of the organizations and their problems are to gather 'the broadest possible critical look at the problem situation but gradually to focus down on those aspects most crucial to the organization at that point in its history' (Jackson, 2001). The task during the creativity phase is to use systems metaphors as organizing structures to help managers and other stakeholders think creatively about their enterprises or problem situations. Different metaphors focus attention on different aspects of a research object's functioning. The outcome from the creativity phase is a set of crucial issues and concerns, highlighted by particular metaphors that then become the basis for a choice of appropriate systems intervention methodology. After the crucial problems are identified, the task during the choice phase is to choose an appropriate systems-based intervention methodology or set of methodologies to address the problem situation as revealed by the examination conducted in the creativity phase. The tools provided by TSI to help with this phase are the system of systems methodologies and, derived from that, knowledge of the particular strengths, limitations and weaknesses of different systems methodologies. The task during the implementation phase is to use a particular systems methodology or systems methodologies to arrive at and implement specific proposals. The result of this stage is coordinated change brought about in those aspects of the organization currently most vital for its efficient, effective and ethical functioning. A summary of this three-phase meta-methodology of TSI[2] is shown in Table 1.

CST and TSI were introduced into management science in such a way that problem contexts were assumed to be six: mechanical–unitary, mechanical–pluralist, mechanical–coercive, sys-

[2]The introduction of CST and TSI in this paper is based on Jackson's book (2000).

Table 1. The three-phase TSI meta-methodology

	Creativity	Choice	Implementation
Task	Highlight concerns, issues and problems	Choose an appropriate systems-based intervention methodology (or methodologies)	Arrive at and implement specific change proposals
Tools	Systems metaphors	The 'system of systems methodologies' and knowledge of the strengths and weaknesses of different methodologies	Systems methodologies employed according to the logic of TSI
Outcome	Dominant and dependent concerns, issues and problems	Dominant and dependent methodologies chosen for use	Highly relevant and coordinated change, improving efficiency, effectiveness, ethicality, etc.

Adapted from Jackson (2000).

temic–unitary, systemic–pluralist and systemic–coercive. Given the grid of problem contexts, systems methodologies were classified into different groups according to the different problem contexts. TSI advocates combining metaphors, the system of systems methodologies and knowledge of the individual systems approaches in an interactive manner that is deemed to be particularly powerful and fruitful. In addition, TSI uses a range of systems metaphors to encourage creative thinking about organizations and their problems. These metaphors are linked by a framework (i.e. the system of systems methodologies (SOSM)) to various systems approaches, so that once agreement is reached about which metaphors are most relevant to an organization's concerns and problems, an appropriate systems-based intervention methodology or set of methodologies can be employed. The choice of an appropriate systems methodology will guide problem solving in a way that ensures that it addresses what the main concerns are of the particular organization involved (Midgley, 2000).

As CST reconstructed systems thinking upon the foundation of pluralism, it makes users respect the strengths of the various trends in systems thinking and diversity of theories and methods; consequently, based on a review of strengths, limitations and weaknesses of the theories and methods, intervention is made by using them in a cohesive and sophisticated manner; as a result, the effectiveness of the methodologies and tools is improved in a variety of complex and dynamic circumstances. To apply CST and TSI into organizational knowledge management, first we have to recognize the specific meanings of knowledge in different disciplines and, second, we have to classify it into different dimensions and select appropriate methods to 'manage' knowledge.

KNOWLEDGE INTERPRETATIONS IN VARIOUS FIELDS

Knowledge management is not a new topic to organizations. One example of a systematic study of knowledge in organizations is R&D activity and its management. However, overwhelming attention to knowledge-oriented research activities and parallel activities did not appear until the early 1990s in catering for the challenges of the 'knowledge society' (Drucker, 1969, 1993; Bell, 1973; Toffler, 1990). Even though academics and practitioners agree on the importance of knowledge in economic activities, they are of divergent opinion concerning the content and interpretation of the term 'knowledge'. People discuss the same term but differ in their interpretations of this rich word that shapes the diverse ways of thinking and subsequent principles of action. They are all supported by their philosophical underpinnings and sophisticated theories, even those involving conflict, which enrich human understanding of knowledge but inevitably increase the difficulty of mastering it. In the following sections, we re-examine the meaning of knowledge in a general sense, in

philosophy, social theory and the discipline of information technology (IT).

General Definition of Knowledge

Most people intuitively relate knowledge to science (natural sciences, social sciences and humanities). In dictionaries, 'science' is simply explained as knowledge. In the *Concise Oxford Dictionary* (8th edition) 'science' is defined as '(1) a branch of knowledge conducted on objective principles involving the systematized observation of and experiment with phenomena, esp. concerned with the material and functions of the physical universe; (2) systematic and formulated knowledge, esp. of a specified type or on a specified subject or the pursuit or principles of this; (3) an organized body of knowledge on a subject'. In the *Longman Dictionary of Contemporary English* (3rd edition), 'science' is explained as 'knowledge about the world, especially based on examination and testing, and on facts that can be proved'. When people talk about knowledge, they often explicitly or implicitly mean science. However, in view of contemporary knowledge science, science is one of the special kinds of knowledge that are systematic, formulated, organized or proved, based on logic or experiments and articulated in words, scientific formulae, data, codified procedures or universal principles. Moreover, it can be communicated and shared among individuals.

In the *Longman Dictionary of Contemporary English* (3rd edition), 'knowledge' is defined as: '(1) what a person knows: the facts, information, skills, and understanding that one has gained, esp. through learning or experience; (2) the state of being informed about something; awareness'. From this definition, knowledge is what the knower knows. It closely relates to the knower and no human judgment is involved. In the *Concise Oxford Dictionary of Current English*, 'knowledge' is defined as: '(1) (a) awareness or familiarity gained by experience (of a person, fact, or thing); (b) a person's range of information (*is not within his knowledge*) (2) (a) a theoretical or practical understanding of a subject, language, etc. (*has a good knowledge of Greek*) (b) the sum of what is known (*every branch of knowledge*); (3) Philos. true, justified belief; certain understanding, as opposite to opinion'. In this explanation knowledge contains broad meanings. It includes not only what the knower knows (awareness, familiarity, a person's range of information, which all depend on the knower and no judgment is made about them) but also what is known by others (theoretical or practical understanding of a subject, language and the sum of what is known, which is not merely what is known by others but should be theoretical especially to some branch), as well as 'true, justified belief; certain understanding, as opposite to opinion'. It extends knowledge from what a person knows to what others know. In *Webster's Third New International Dictionary of the English Language*, 'knowledge' is defined as: '(1) (a) the fact or condition of knowing something with a considerable degree of familiarity gained through experience of or contact or association with the individual or thing so known (*a thorough knowledge of life and its problems*); (b) acquaintance with or theoretical or practical understanding of some branch of science, art, learning, or other area involving study, research, or practice and the acquisition of skills (*knowledge of advanced mathematics*); (2) (a) the fact or condition of being cognizant, conscious, or aware of something (*the knowledge that it was really important*); (b) the particular existent range of one's information or acquaintance with facts: the scope of one's awareness: extent of one's understanding; (3) the fact or condition of apprehending truth, fact, or reality immediately with the mind or senses: perception, cognition (*intellective knowledge*); (4) the fact or condition of possessing within mental grasp through instruction, study, research, or experience one or more truths, facts, principles, or other objects of perception: the fact or condition of having information or of being learned or erudite (*a man of great knowledge*); (5) the sum total of what is known: the whole body of truth, fact, information, principles or other objects of cognition acquired by mankind (*adding to the vast store of knowledge*)'. This definition emphasizes a considerable degree of familiarity and understanding to what the knower knows and connects knowledge with mental processes.

From the above examination, we can discern that there exist many different perceptions of the

term 'knowledge'. Knowledge could be just what is known without any judgment. Knowledge to some knower is just what he knows; its extension to others should attach some objective or subjective judgment. Although some people still think merely knowing is not enough but a considerable degree of familiarity and understanding to what is known also should be considered, one thing is certain: knowledge has a much broader, deeper and richer meaning than science or information. Knowledge does not only mean scientific knowledge but also experience, skills, understanding, learning, awareness, familiarity, information and facts people have. However, if we accept the concept of knowledge in this wide viewpoint when we discuss knowledge and knowledge management, we take the risk of capturing nothing but overly general descriptions. Knowledge as both means and tools of production in creating wealth in the knowledge society should have more accurate meanings in it to businesses.

Knowledge in Philosophy

The philosophical inquiry of knowledge in the West is known as 'epistemology'. Epistemology, or the theory of knowledge, is concerned with how we know what we know and what justifies us in believing what we know. There are the three major aspects concerned: the nature of knowledge; the origin of knowledge; and the reliability of knowledge. Western philosophers generally agree that knowledge is 'justified true belief', which can be obtained by reasoning in terms of rational, logic, mind deduction (such as Plato and Descartes[3]) or by empirical induction from sensory experiences (Aristotle, 1928, and Locke[4]), or by synthesis of the two (Kant; Hegel; Marx;[5] Russell, 1961, 1989). Philosophers tried to pursue something called the 'truth' that is objective. They also saw knowledge as an entity that can be captured, categorized, stored and learned. It is separated from any individual being as an inanimate 'thing' or 'object'. Never-

[3]To Plato, there is nothing worthy to be called 'knowledge' to be derived from the senses, and the only real knowledge has to do with concepts. Only the mind can reach existence, and we cannot reach truth if we do not reach existence. It follows that we cannot know things through the senses alone, since through the senses alone we cannot know that things exist. Therefore knowledge consists in reflection, not in impressions, and perception is not knowledge, because it 'has no part in apprehending truth, since it has none in apprehending existence'.

Descartes: 'While I wanted to think everything false, it must necessarily be that I who thought was something; and remarking that this truth, *I think, therefore I am*, was so solid and so certain that all the most extravagant suppositions of the sceptics were incapable of upsetting it. I judged that I could receive it without scruple as the first principle of the philosophy that I sought.'

[4]Aristotle's 'Out of sense-perception comes to be what we call memory, and out of frequently repeated memories of the same thing develops experience; for a number of memories constitute a single experience. From experience again, i.e. from the universal now stabilized in its entirety within the soul, the one besides the many which is a single identity within them all, originate the skill of the craftsman and the knowledge of the man of science, skill in the sphere of coming to be and science of being. We conclude that these stages of knowledge are neither innate in a deterministic form, nor developed from other higher states of knowledge, but from sense-perception.' Though Aristotle's argument is empiricist, he has been considered the authority on logic or rational reasoning.

Locke's doctrine is that all our knowledge (with the possible exception of logic and mathematics) is derived from experience. He says: 'Let us suppose the mind to be, as we say, white paper, void of all characters, without any ideas; how comes it to be furnished? Whence comes it by that vast store, which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer in one word, from experience: in that all our knowledge is founded, and from that it ultimately derives itself.' 'Perception is the first step and degree towards knowledge, and the inlet of all the materials of it.' Our ideas are derived from two sources: (a) sensation and (b) perception of the operation of our own mind, which may be called 'internal sense'. Since we can only think by means of ideas, and since all ideas come from experience, it is evident that none of our knowledge can antedate experience.

[5]Kant tries to prove that although none of our knowledge can transcend experience, it is, nevertheless, in part a priori and not inferred inductively from experience. The part of our knowledge that is a priori embraces, according to him, not only logic, but much that cannot be included in logic or deduced from it. He makes the distinction between 'analytic' and 'synthetic' propositions and 'a priori' and 'empirical' propositions.

Hegel asserts that the real is rational, and the rational is real. What to the empiricist appear to be facts are, and must be, irrational; it is only after their apparent character has been transformed by viewing them as aspects of the whole that they are seen to be rational. The whole, in all its complexity, is called by Hegel 'the Absolute'. The Absolute is spiritual; Spinoza's view, that it has the attribute of extension as well as that of thought, is rejected. He emphasizes both logic (the nature of reality can be deduced from the sole consideration that must be not self-contradictory) and the 'dialectic' (which consists of thesis, antithesis and synthesis). Knowledge as a whole has its triadic movement. It begins with sense-perception, in which there is only awareness of the object. Then, through sceptical criticism of the sense, it becomes purely subjective. At last, it reaches the stage of self-knowledge, in which subject and object are no longer distinct. Thus self-consciousness is the highest form of knowledge.

In Marx's view, all sensation or perception is an interaction between subject and object; the bare object, apart from the activity of the percipient, is a mere raw material, which is transformed in the process of becoming known. Knowledge in the old sense of passive contemplation is an unreal abstraction; the process that really takes place is one of *handling* things. 'The question whether objective truth belongs to human thinking is not a question of theory, but a practical question' he says. 'The truth, i.e. the reality and power, of thought must be demonstrated in practice'.

theless, knowledge (i.e. 'justified true belief') is in essence a kind of belief, which is true (or which people believe is true) because it has been justified in some way by some means via reasoning or sensory experience to the extent of human ability.

Another important strand of knowledge theory was developed by Michael Polanyi. He argued that knowledge is inherently personal. Polanyi (1962) called attention to the necessity of deriving theories from facts rather than facts from theories. He claimed that 'knowing what' and 'knowing how' are interdependent. In his words, 'neither is ever present without the other' (Polanyi, 1983). Polanyi said:

> I am looking at Gestalt as the outcome of an active shaping of experience preformed in the pursuit of knowledge. This shaping and integrating I held to be the great and indispensable tacit power by which all knowledge is discovered and, once discovered, is held to be true.

Polanyi divided human knowledge into two dimensions: explicit knowledge (written and formalized) and tacit knowledge (the action related and unformulated) (Polanyi, 1959). The tacit dimension of knowledge is the most important knowledge an individual has, but it cannot be articulated. Focusing on human's capacity to think, he declared that the opinion that scientists hit on discoveries merely by trying everything that crosses their minds follows from an inability to recognize a human's capacity for anticipating the approach of 'hidden' truth (Polanyi, 1983). To some person with less education in physics, a statement of scientific knowledge like a law in physics makes no sense. It makes sense only to those who have the ability to understand what the law expresses. Polanyi insisted that knowledge is not gained by an objective flow of events and the necessary outcome of a determined scientific endeavour, but is grounded in such human conditions as the sense of beauty and passion. What Polanyi taught here is that in reality all knowledge has an ineradicably personal element. Polanyi's insight on tacit knowledge uncovered the mystery of discovery, invention and creation by knowledge agents and emphasized the agents' capacity of thinking, doing or acting. His argument on personal knowledge shed light on our systems thinking for knowledge management. As the ***capacity*** of thinking and doing can be realized only after action, the process of thinking or doing is that of knowledge generation and application, which makes the ***process*** of action imperative in acquiring knowledge. His thoughts provided the theoretical origin for valuing knowledge workers' work.

To sum up, in philosophy there are two different dimensions in knowledge: one relates to the scientific, logical or objective dimension; another to the subjective dimension. For the objective dimension, knowledge is like a 'thing' or 'object' that can be articulated, captured and stored, but only certain people with enough capacities can fully understand its subjective dimension, that is, the meaning that the 'thing' or 'object' represents. Since the ability to perceive is inseparable from applying that ability to perceiving action, it is reasonable to consider the subjective aspect of knowledge as process knowledge. Since all knowledge is understood as a kind of belief, the different elements embedded in knowledge allow some knowledge (such as knowledge in natural sciences) to transcend culture, value and national boundaries and to be wholly perceived; however, knowledge closely related to culture, value and ethics can only be shared within certain groups, races or countries.

Knowledge in Social Theory

Daniel Bell (1973) defined 'knowledge' in a broader sense as 'a set of organized statements of facts or ideas, presenting a reasoned judgment or an experimental result, which is transmitted to others through some communication medium in some systematic form' or in general meaning as 'which is objectively known, an intellectual property, attached to a name and a group of names and certified by copyright or some other form of social recognition'. He added that knowledge involves new judgments (i.e. research and scholarship) or new combinations of older judgments (i.e. textbook and teaching),

which makes theoretical knowledge more important as it can be translated into many varied circumstances. Bell argued that the post-industrial society is a knowledge society for two major reasons: one is that 'the sources of innovation are increasingly derivative from research and development (and more directly, there is a new relation between science and technology because of the centrality of theoretical knowledge)', another is 'the weight of the society, measured by a large proportion of GNP and a large share of employment, is increasingly in the knowledge field'. Stehr (1994) termed 'knowledge' as a capacity for social action, a condition for the possibility of social action, which indicates strongly that the material realization and implementation of knowledge depend on or are embedded within the context of specific social and intellectual conditions. He expressed that his book *Knowledge Societies* was 'written in response to the fundamental observation that contemporary science is not merely, as was once widely thought, the key and solution to the mysteries and miseries of the world, but is the becoming of aworld. . . . Our world is increasingly produced by science and our understanding of these transformations increasingly relies on ideas generated in science'. The terms 'science' and 'scientific' have to include not only the natural sciences but also the social sciences and humanities. When social theorists talk about the relationship of knowledge to economic growth or its influence on social and cultural aspects, knowledge usually means scientific knowledge and its implementation, called technology, usually in the form of technological artefacts (Adorno, 1973; Merton, 1973; Lane, 1966).

Knowledge in nature has fundamental differences from other production factors. It is return increasing rather than return diminishing. Stehr (1994) said 'if sold, knowledge, ideas, and information enter other domains and yet remain within the domain of their producer. Knowledge does not have zero-sum qualities. Knowledge is a public good, when revealed, knowledge does not lose its influence'. As a kind of asset in economy, scarcity is an important feature that at some degree decides its economic value. It is for these reasons that knowledge in contemporary scientific enterprise now and in the scientific community in the past cannot be exactly the same. Drucker (1969) asserted that:

> Knowledge as normally conceived by the 'intellectual' is something very different from 'knowledge' in the context of 'knowledge society' or 'knowledge work' . . . knowledge, like electricity or money, is a form of energy that exists only when doing work. The emergence of the knowledge economy is not, in other words, part of 'intellectual history' as it is normally conceived. It is part of the 'history of technology', which recounts how man puts tools to work.

Drucker defined 'knowledge' as information that 'changes something or somebody either by becoming grounds for action, or by making an individual or an institution capable of different and more effective action' (Drucker, 1989). Knowledge in the knowledge economy is effective knowledge or 'specialized knowledge', knowledge workers with specialized knowledge are doctors, lawyers, teachers, accountants, chemical engineers, computer technicians, software designers, analysts in clinical labs, manufacturing technologists and paralegals (Drucker, 2001).

Knowledge in Information Technology

In the IT area knowledge is regarded as a kind of information, and knowledge management is just a higher level of information management. To most researchers and practitioners, knowledge is 'reasoning about information and data to actively enable performance, problem-solving, decision-making, learning, and teaching' (Beckman, 1997); 'information that has been organized and analyzed to make it understandable and applicable to problem-solving or decision-making' (Turban, 1992); or 'a fluid mix of framed experiences, values, contextual information, and expert insight' (Davenport, 1997; Davenport and Prusak, 1998). In an information perspective, Boisot (1998) defined knowledge as 'a capacity that is built on information extracted from data or the set of expectations that an observer holds with

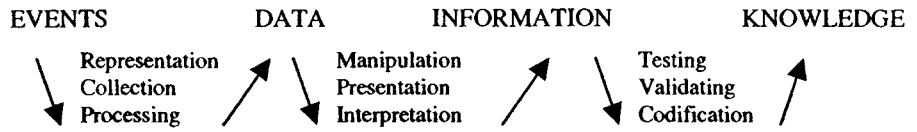

Figure 1. Towards conceptualizing knowledge (Source: Earl, 1994).

respect to an event'.[6] He put his object or issue into a platform of 'information-space (I-space)' and focused on information through abstraction, codification and diffusion that brings out the extent to which knowledge assets and physical assets substitute for each other in economic processes. In this way, corporate culture and organizational processes are connected with information environment; for this reason, the economic value of knowledge assets is discussed in the face of information goods. In short, creating knowledge implies a process of generating insights through extracting information from data. Earl (1994) took Skandia and Shorko as examples because they are well known for building knowledge-based strategies enabled by IT. Knowledge was viewed as 'what we know, or what we can accept we think we know and has not yet been proven invalid, or what we can know' at the three levels: science (accepted law, theory and procedure); judgment (policy rules, probabilistic parameters and heuristics); and experience (which is no more than transactional, historical and observational data to be subjected to scientific analysis or judgmental preference and also to be a base for building new science and judgments). Science was viewed as accepted knowledge—the highest level of knowledge; judgment as workable knowledge; and experience as potential knowledge—the lowest level of knowledge. Because the fundamental assumption in this perspective is based on the belief that knowledge comes from information, information from data, and data from events (see Figure 1), IT as the platform of know-how or enabler of turning knowledge into valuable industrial commodity was placed at the centre for consideration.

Based on their position, researchers in the IT field believe knowledge management is to construct information management systems, IT infrastructures, decision support systems, expert support systems, knowledge repositories or data warehouses through both hard and soft technologies (computer, Internet, intranet, groupware, knowledge discovery in database, data mining or other information techniques). Truly, computer and information technology do not only facilitate human communication but also, as a powerful means, help people create, discover and apply new and existing knowledge from information, data and past events. Knowledge bases and intranets are the most popular ways of enabling knowledge and implementing knowledge management.

We realize that knowledge can be interpreted as different things from the philosophical underpinnings of their disciplines. The difference between knowledge and science, and between knowledge and information, is also declared. Their relationship is like that of a set and elements of the set in mathematics. Science and information are the components of knowledge. Knowledge is beyond science and information. Knowledge displays its meaningful utility to the economic community only when knowledge is properly utilized by knowledge agents.

KNOWLEDGE AND KNOWLEDGE MANAGEMENT

By using CST, we have reviewed the different interpretations of knowledge in a variety of disciplines or interdisciplinary fields. When we move on to a detailed examination of knowledge and its management in organizations, we divide knowledge into two levels: personal knowledge and organizational knowledge.

[6]Boisot (1998) further explained, 'as a resource, man can either be viewed as a source of labor power, i.e., as a physical phenomenon, or as a source of knowledge, i.e., as an information phenomenon'.

Personal Knowledge

From the general definition of knowledge it is known that at individual level personal knowledge is what the person knows as well as his skill and ability that would determine or help him make decisions and take action. This statement is quite general and does not involve any judgment. Expanding this statement to others, what a knower knows involves the person's personal judgment. He can use fixed standards or rules, whether scientific means or subjective opinions, to judge or evaluate whether what the others know is knowledge. If the two parts (the knowing system and the evaluation system) were put together, facts, experience, learning, familiarity, awareness, understanding, skill and ability can be considered as an individual's personal knowledge.

Personal knowledge has to be evaluated by an organization or society when it is utilized. Personal knowledge in the knowledge society is composed not only of Drucker's specialized knowledge acquired in formal and advanced education rather than through apprenticeship but also Polanyi's tacit knowledge with which one acquires and applies his specialized knowledge. When we refer to personal knowledge in this paper, we mean a mixture of theory, technique, learning, capacity and skill owned by individuals. Considering the important influence of one's value systems, we also include personal value systems like ethics and morals in personal knowledge.

By and large, knowledge management can involve everyone in an organization (Wiig, 1994, 1995; Nonaka and Takeuchi, 1995); however, in a strict sense, only knowledge workers,[7] whose jobs require formal and advanced schooling and who mainly work with their brains (or hands—even if they work with hands, the manual work is based on using systematic theory and technology), are involved.[8] Clearly, personal knowledge belongs to the person who has it rather than the organization he works for. An individual's knowledge is not taken for granted as organizational knowledge, but it could be a potential organizational knowledge. It can be utilized and leveraged by an organization and part of it can be 'externalized' within the organization and transferred into the domain of an organizational knowledge system in certain environments (Nonaka and Konno, 1998; Nonaka *et al*., 2000).

Organizational Knowledge

At the organizational level (based on the discourse of knowledge in philosophy, in social theory, in knowledge economy, and the characteristics of economic organization, for the convenience of strategic management) we divided organizational knowledge into two parts: static substance knowledge and dynamic process knowledge. Static substance knowledge mainly includes explicit knowledge owned by organizations in the form of patents, publications, manuals or written know-how, regulations, institutions, etc; dynamic process knowledge relates to actions carried out by knowledge workers who use personal knowledge and substance knowledge for knowledge application and creation. Following TSI's analytical procedure, we choose two metaphors, cookbook and cooking, to demonstrate our reasoning of the knowledge dichotomy in an organizational context and justification of our classification of organizational knowledge for the purpose of knowledge management.

In our view, cookbooks are the static substance knowledge, while cooking is dynamic process knowledge. Any cookbook as a form of explicit knowledge can be communicated and distributed among people. Cookbooks have objective features and belong to scientific or theoretical knowledge. Varieties of cookbooks are located in libraries, bookstores or on the Internet, but to be competitive and attractive restaurants still need unique cookbooks for survival in the marketplace. The economic value of cookbooks cannot be well recognized without cooks with good personal knowledge to use them. Likewise, not everyone can really master and apply knowledge in cookbooks as skilled cooks do. Process knowledge or the knowledge

[7]For further discussion on knowledge workers, see Gao *et al*. (2000).
[8]Leonard-Barton's (1992, 1995) four core capabilities and four kinds of knowledge-building activities are to the point here.

transferring static substance knowledge into products or services becomes crucial in realizing the value of book knowledge. Cooking is an operational process, and it needs technical knowledge embedded in cooks and their personal skills and subjective judgment. The full extent of process knowledge can be realized only when experienced cooks practise cooking. Without the process of practice, it is difficult to grasp and maintain the process knowledge of cooking and to obtain economic value from cookbooks.

Any organization needs both static substance knowledge like 'cookbooks' and dynamic process knowledge like 'cooking' to realize its vision and mission. Knowledge workers in an organization are like 'cooks' in our metaphoric example who carry out creating knowledge (writing and compiling the 'cookbooks') and cooking. Our example shows that a knowledge worker's productivity is to a knowledge-intensive organization as a cook's productivity is to a restaurant.

Organizational Static Substance Knowledge

Static substance knowledge is impersonal. It can be accumulated and exists over time. Theoretically, most substance knowledge can be communicated, learned and shared. As both an organization's means and one of its production factors to realize an organizational end, it makes up the organization-specific knowledge systems for the specific organization. To explore the details of static substance knowledge by means of CST, we view organizational substance knowledge as a system, and divide it into three hierarchical levels: visionary knowledge, objective and/or subjective knowledge and generic knowledge.

Visionary knowledge, the highest-level knowledge in the hierarchical system, means an organizational value system in the form of value, vision and mission. It reflects the organization's ethical and moral criteria. It relates to collectively subjective judgment rather than logical thinking, but it is the most important intangible asset to the organization and basic driving force to both the success of an organization and the achievement of individuals. The knowledge system guides individual behaviour in two aspects: attitude to oneself (self-esteem, self-constraint and self-cultivation) and attitude to others (honesty, compassion and humanity). These aspects embody the quality of 'organization citizenship behaviours' (Turnipseed, 2002; Bateman and Organ, 1983; Organ, 1990).

The reason we consider organizational value system as visionary knowledge is that in modern society it is impossible for an individual human being to possess all the specialized knowledge necessary for work. Cooperation and sharing knowledge are inevitable, but the necessity of cooperation among knowledge workers is different from that among manual workers. Cooperation among manual workers aims at coordinating their work or making the work go smoothly; knowledge workers' cooperation focuses on exchanging and sharing thoughts, ideas and personal knowledge that is based on trust. Trust is not a thing that naturally happens among people; it needs shared ethics and morals in its inception. Trust also determines the quality and ability of organizational knowledge sharing during knowledge activities (creation and application) among knowledge workers.

Another reason for viewing ethics and morals or values as the highest visionary knowledge is that any organization or individual equipped with modern advanced science and technology without restraint and regulation of ethics, morality and humanity would have a potential negative impact on human beings and society.

Both of these reasons make visionary knowledge a prerequisite in knowledge management. Systems science has a tradition of emphasizing ethics and morality. Churchman (1970, 1982) and Ackoff (1974) emphasized these aspects. In CST, the basic principles (critical awareness, social awareness, emancipation and pluralism) focus on these aspects.

Objective and/or subjective knowledge consists of three parts: scientific knowledge, technical knowledge and managerial knowledge. Scientific knowledge is objective, systematic, theoretical and proven knowledge, which is derived from scientific thinking and scientific methods based on facts and experiments. It is the resource and foundation of technical knowledge. Technical knowledge means applied scientific knowledge and expertise, which are at the core of organizational

knowledge systems. The operation and service of enterprise are usually based on its technical knowledge. An organization's competence of innovation and advantage of competition lie in both its scientific knowledge and technical knowledge. They are usually in the artefacts of copyright and patents in an enterprise. As to managerial knowledge, it is the management techniques within the extent of a company for its operation and service which decide the efficiency and effectiveness of the enterprise's operation. It is reflected in corporate regulations, rules, structures, procedures and organizational daily management activities. Each of them is crucial to an organization and functions differently: scientific knowledge determines the organization's status and long-term standing in industry; managerial knowledge (without unified and fixed standards) determines the organization's effectiveness and efficiency; and technical knowledge decides its productivity. Although they are different in nature, they usually intertwine together and interact with each other. All these three parts of organizational knowledge can also be synthesized in an organization's expert system and decision-support system. An enterprise, based on its financial ability and real situation, can choose parts or all of them as its core competences.

Generic knowledge embraces information and data collected and gathered for an organization's purpose. 'Data' consists of symbols of known facts or events without interpretation; 'information' is data with meaning or data in context (Davenport, 1997; Spek and Spijkervet, 1997). Data and information are not called knowledge, but they can be converted into knowledge after being properly interpreted. They are the foundation and materials of knowledge, so are viewed as the subsystems of organizational knowledge. A substantial investment is needed for an organization to own a high-quality database or data warehouse and a well-organized information system. Such a system also requires close cooperation of experts in various fields like statistics, computer and information technology, and software engineering.

Each part of the knowledge system described above has different characteristics and plays a different role in an organization; therefore, different criteria are needed to evaluate it and different approaches are needed to deal with it. Scientific knowledge can be verified or falsified; technical knowledge is evaluated by advancement, novelty and applicability; managerial knowledge can be proven by the operational performance of the organization. The criteria for evaluating data are objectivity, accuracy and reliability; the criteria for evaluating information are reliability, simplicity and timeliness. Because the static substance knowledge here is just a set of theoretical concepts, in reality organizations have to decide what kind of knowledge system is most suitable to the practical situation they face and how best to establish a knowledge system to fit with their ability.

Organizational Dynamic Process Knowledge

To accumulate and create business knowledge is not the true end of most organizations; knowledge is an important means for them to fulfil organizational objectives. Therefore, it is important to effectively and efficiently transfer static substance knowledge and personal knowledge into products and services. This dynamic process knowledge depends on human activity. It is at this point that process knowledge is viewed as human practical activity.

Due to the complexity of the substance knowledge system (each of its subsystems has different characteristics and hypotheses and needs different standards of evaluation), human activities involving it (the activities of creating, acquiring, codifying, distributing, transferring and utilizing substance knowledge and their personal knowledge, i.e. organizational learning and personal learning) have different characteristics. To ensure a competitive advantage and sustainable development, every knowledge-intensive organization must make decisions based on various interests, those of the organization, of members and groups within the organization, of society and of the natural environment. If Ackoff's well-developed corporation's pursuit of beauty is the vision of the organization in its highest level of hierarchy in the past, now it is the goal that the corporation must consider in order to attract and maintain its core experts and

specialists.[9] From the view of systems thinking, we consider human activity as a system.

A human activity system is an assembly of knowledge workers and other resources (both hard and soft ones) organized as a whole to accomplish organizational purposes. Following the logic of CST and TSI, human activity can be classified into three kinds of subsystems: high-autonomy activity, autonomy activity and deterministic activity. High-autonomy activity means that the activities are carried out by guidelines based on the organizational vision and mission. Employees or knowledge workers carry out the activities of high-level autonomy in almost every aspect, especially financial and human-resource aspects. These activities closely relate to advanced scientific and technical knowledge. People who carry out autonomous activities also have work autonomy (e.g. they can decide what to do, how to do it and by what means to do it), but the activities have a clearly defined purpose. The action of knowledge workers must meet well-defined goals. General R&D activity usually belongs to this subsystem. The deterministic activity subsystem, as its name indicates, is such an activity system in which not only the purpose of the activities but also the objectives of the activities are determined. Therefore, the knowledge workers cannot decide what to do, but they have the right to decide how to do it and by what means to do it. To carry out these activities, usually certain procedures should be followed. Activities that develop static substance knowledge systems, transfer substance knowledge into products and services, or gather, collect and store information and data fall into this subsystem.

In the above discussion, we first categorized business-related knowledge in economic organizations into two parts: static substance knowledge and dynamic process knowledge. Static substance knowledge is treated as a static knowledge system. As dynamic process knowledge cannot be separated from human action, it is viewed as a human activity system (see Table 2). Following the logic of TSI, the next step is to explore the essence or 'crucial issues and concerns' of knowledge management. Then, we can focus our attention on seeking proper approaches to support knowledge management effectively and efficiently.

[9]In his words, 'the best kind of life is one in which the difference between work and play is zero' (Novak, 2000).

Knowledge Management in Organizations

In economic organizations, the main task of knowledge management, like the management of other production factors, is to realize the organizational mission. According to our knowledge dichotomy of static substance knowledge and dynamic process knowledge, knowledge management in an organization is evidently composed of two aspects: managing static substance knowledge and managing dynamic process knowledge. Managing static substance knowledge can be either directly dealing with substance knowledge like patents or copyrights (Petrash, 1996) or managing the activities of establishing and developing static substance knowledge systems. As knowledge workers carry out the activities, managing static substance knowledge, to some extent, is managing the activities of knowledge workers. As dynamic process knowledge is viewed as a human activity system, in this sense knowledge management, except directly dealing with 'raw' substance knowledge, is to manage human activities.

It is unrealistic for knowledge managers to personally involve themselves in detailed activities. Their task is to offer both 'hard' and 'soft' support to enable a high-quality environment for knowledge workers to effectively and efficiently engage in knowledge-related activity. Knowledge managers unnecessarily possess detailed specialized knowledge, but an understanding and insight into static substance knowledge systems and the impact of management knowledge on human activity systems are a prerequisite for them to effectively implement knowledge management.

Multifaceted knowledge in an organization is necessary to direct activities that have different characteristics (Gao *et al.*, 2002). Knowledge workers from various fields with different backgrounds and unique specialized knowledge also have different living and working desires with

Table 2. Organizational knowledge

Organizational Knowledge	Name		Criteria	Function
Static Substance Knowledge System	Visionary knowledge	Vision Mission Ethics Moral	Humanity Justice Fairness Honesty	Faculty to create and apply knowledge
	Objective and/or subjective knowledge	Science	Justification Falsification	Industrial fields
		Technology	Advancement New Applicability	Status in industry
		Management	Performance Applicability	Effectiveness Efficiency
	Generic knowledge	Information	Reliability Simplicity Timeliness	One of the main foundations of knowledge
		Data	Objectivity Accuracy Reliability	Foundation of information
Dynamic Process Knowledge or Human Activity System (HAS)	High-autonomy HAS (defined mission)		Publications Copyrights Patents New products and service	Competitive advantage (long-term R&D)
	Autonomy HAS (defined goals)		As above	Core competence (mid-term R&D)
	Deterministic HAS (defined problems)		New products and service Patents Publications Copyrights	Innovation (products and service R&D or IT-related activity)

different purposes. Multiple approaches are need to tackle the complexity of human activities and the diversified purposes of knowledge workers, teams, organization and the community, which are changed by both time and situation. Critical awareness and social awareness alert knowledge managers and workers to thinking beyond the research object. Human emancipation takes humanity or ethics and morals into consideration to realize the potential of knowledge workers to improve the condition of both the members and society. Pluralism requires knowledge managers and workers to appreciate different theories, methodologies, approaches, models and techniques and to make trade-offs between strengths and weaknesses. Critical awareness, social awareness, human emancipation and pluralism can be realized through sufficient communication and dialectic debates by using the interpretive systems approaches (many of them focus on offering techniques to support understanding interwined with both subjectivity and objectivity through discussion, communication, debate and negotiation) in TSI (Jackson, 2000). Interactive dialogues and constructive debates within an organization or community can bring love, care, trust and beauty into activities by enhancing the members' mutual understanding that is the guarantee of perfect cooperation, which leads to both the success of the organization and the satisfaction of its members.

CST and TSI, as a thinking guide and a management technique, make both knowledge managers and workers the leading figures in their specialties equipped with modern systems thinking. They allow knowledge managers to appreciate and utilize new ideas and techniques like: (1) covert leadership (Mintzberg, 1998), (2) synthesizing knowledge-related activities (Wiig, 1994), (3) energizing 'Ba' with love, care, trust, commitment and security (Nonaka, 2000), (4) care in knowledge creation (von Krogh, 1998) and (5) some interpretive systems approaches[10] in TSI to understand and inspire knowledge workers. Likewise, CST and TSI make knowledge workers appreciate and understand each other.

The spirit of creativity in TSI can broaden the minds of knowledge managers and workers to critically and continuously 'sweep in' 'new' ideas, approaches, models and techniques in practice. The morale of individual learning will lead to continuous organizational learning, which is a crucial element for a qualified competitive enterprise in an ever-changing world.

CST and TSI not only help knowledge managers to manage knowledge activities as a whole, but they also offer technical support to knowledge workers for engaging in knowledge-related work. TSI itself classifies problem contexts into unitary, pluralist and coercive situations and matches them with functionalist systems approaches, interpretive systems approaches and emancipatory systems approaches, respectively (Jackson, 2000). If we consider activities related to visionary and management knowledge subsystems belonging to a pluralist situation for social and cultural reasons, it is taken for granted that the interpretive-systems approaches naturally match to the approach group for supporting this kind of activity. Since the activities related to science, technology, information and data usually have a defined goal, the functionalist-systems approaches can be matched to this kind of situation. In the case of organizations or employees having their own right to fire or to quit, the coercive situation is ignored here. Because we believe that the cost of time and energy needed to resolve such a problem will be high, we suggest that a convenient way to solve it is to use one's right to fire or quit at a proper point (this is the worst choice, but we think it is appropriate for almost all specialists and ambitious competitive organizations). Although we ignore the coercive situation, it does not mean the emancipatory-systems approaches cannot be used in knowledge management. We believe they are useful to both knowledge managers and knowledge workers engaged in high-autonomy human activity.

TSI already offers a system of systems methodologies to resolve various problems. Based on this system with the spirit of CST and TSI, we can introduce other theories and approaches developed from the fields of management (e.g. R&D management, project management, innovation management, management of technology, organizational behaviour and organizational psychology) like Nonaka and Takeuchi's knowledge creation theory, Leonard-Barton's unique innovation competitive advantage (1992, 1995), Wiig's intelligent action (1994, 1995, 1997), Edvinsson and Malone and Sveiby's visualizing and cultivating intellectual capital or intangible assets (Edvinsson and Malone, 1997; Sveiby, 1997), Petrash's licensing intellectual capital (1996), Boisot's information perspective (1998), Davenport and Prusak's working knowledge (1998; Davenport, 1997), and Choo's explicit and tacit plus cultural knowledge (1998) to mention a few, to form a concrete toolkit for supporting knowledge activities.

This toolkit will be more complex than the original SOSM in TSI in structure and content. Briefly, we know that knowledge managers and knowledge workers utilize different methodologies; the different human activity subsystems also need different approaches to be engaged and managed; the unitary and pluralism of the participants will give another dimension (see Figure 2). Therefore, at least the method base has three dimensions. We hope that through this original work more people will work with us to further explore relevant topics with the philosophy of CST and the spirit of TSI.

[10]Like Churchman's social systems design, Ackoff's interactive planning, Checkland's soft systems methodology, Mason and Mitroff's strategy assumption surfacing and testing, and Warfield's interactive management, etc.

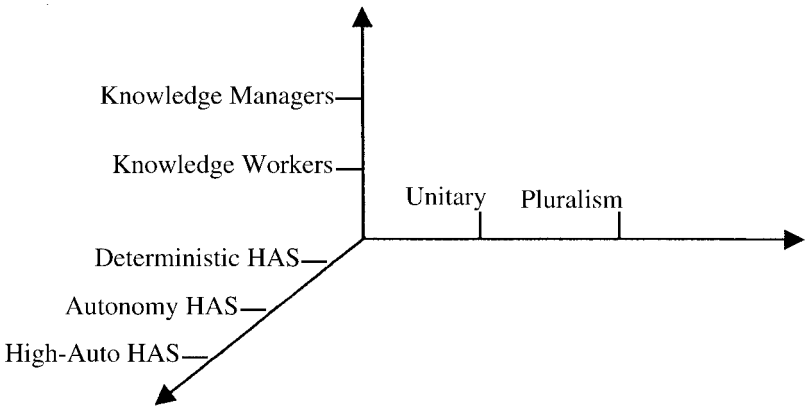

Figure 2. Dimensions of problem contexts

CONCLUDING REMARKS

CST, as a thinking guide, is employed in our research on knowledge and its management. When CST and TSI are introduced into the knowledge management context, we achieve two things. First, a new systems thinking is brought into the analysis of complex situations. Based on a re-examination of different interpretations of knowledge in different fields, we divide knowledge in organizations into two systems: static substance knowledge and dynamic process knowledge. Analysis shows that knowledge management is to manage the activities of knowledge workers via enabling favourable 'hard' and 'soft' environments developed and cultivated by knowledge managers. Second, the introduction of CST and TSI as a meta-philosophy—methodology provides a portal to new thinking and techniques for knowledge managers. They can use it for reference to create enabling environments via critical thinking, interactive dialogue, dialectic debate and collective awareness. For knowledge workers, it also broadens their insights in participating in active communication and organizing their activities in a systematic way.

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