THE KNOWLEDGE SOCIETY NETWORK
AS A SELF-ORGANIZING NETWORK-OF-NETWORKS

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Abstract

While network-based knowledge innovation is increasingly being emphasized in society, the social engineering of networks for effective action is still in its infancy (Scardamalia, 2003). The question of what represents an optional structure of knowledge innovation network remains unanswered. Recent literature, however, hint at a relationship between knowledge innovation and knowledge networks that self-organize. The purpose of this paper is to explore this claim, and to compare the design of a Knowledge Society Network (KSN) to the common design features of a self-organizing network and accordingly suggest further design improvement for the KSN.

Keywords: Knowledge building, self-organizing systems, social networks, innovation.

Introduction

Society is being transformed into a "knowledge society" (Drucker, 1986). The advances and ubiquity of communication and internet technology provide new forms of connectivity for traditionally-dispersed and loosely-bound knowledge workers, transforming the nature and process of knowledge work. As described in a recent UNESCO (2005) report titled *Towards Knowledge Societies*, “The magnitude of technological change, which over recent decades has affected the means of knowledge creation, transmission and processing, have brought a number of experts to hypothesize that we stand on the threshold of a new era of knowledge" (p.47). The Knowledge Society Network (KSN) was created under such background; created as a bold design experiment that aims to maximize society’s innovative capacity by taking advantage of new knowledge media (Scardamalia, 2003; Hong, Scardamalia, & Zhang, 2007). As an innovation driven knowledge network, the KSN has a unique design structure that values sustained idea improvement and opportunistic collaboration that centers around emerging, rather than pre-specified, knowledge works. In some ways, such design is very similar to the design structure of self-organizing networks, which have been highly associated with knowledge-based innovation in recent self-organization literature (Fuchs, 2005; Gloor, 2006; Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). The purpose of this paper is (1) to review literatures broadly concerning the relationships between networked knowledge innovation and the design characteristics of a self-organizing network; and (2) to examine the current design strengths and weaknesses of the KSN and suggests further design improvement.

Innovation

Lately, in academia (Adams, 2005; Bindé, 2005), in the popular press (Twist, 2004), and from government (Canada's New Government, 2007) we hear how important innovation is to the modern world’s economy. The term ‘innovation’, however, can cause confusion. We also hear about creativity, novelty, ideas, ingenuity, and inspiration, to name but a few. Most of these refer to the same thing–a process of creating new knowledge that can be applied to solve problems of real consequence in the world. Homer-Dixon (2001), using the term ingenuity (but noting that it means the same thing as innovation,) defines it as, "… consisting of *sets of instructions* that tell us how to arrange the constituent parts of our social and physical worlds in ways that help us to achieve goals" (p. 21 original emphasis); and Johansson (2006) defines innovation as creative ideas that have been realized. The concept of realization of creative ideas, through action on the sets of instructions, is essential to an understanding of the process of innovation, as ideas are common–it is the sustained work with them to produce something useful that is the hard part, and what really counts in the innovation process (Bereiter, 2002).

The process of innovation is widely misunderstood. The folk conception of innovation involves the creative genius, sitting alone in their house, office, cave, bath, etc., and shouting, "Eureka!" as they come up instantly with a flash of inspiration in which the solution of a complex and difficult problem is instantly solved in detail by their lonely cogitations. Popular conception holds that this is a sole property of genius, and that ordinary people can't be innovative. Nothing could be further from the truth.

Arguably the most mature conception of the innovation process is that put forth by Teresa Amabile (1996). In her *componential model of creativity*, she posits a five stage process of innovation (Figure 1).

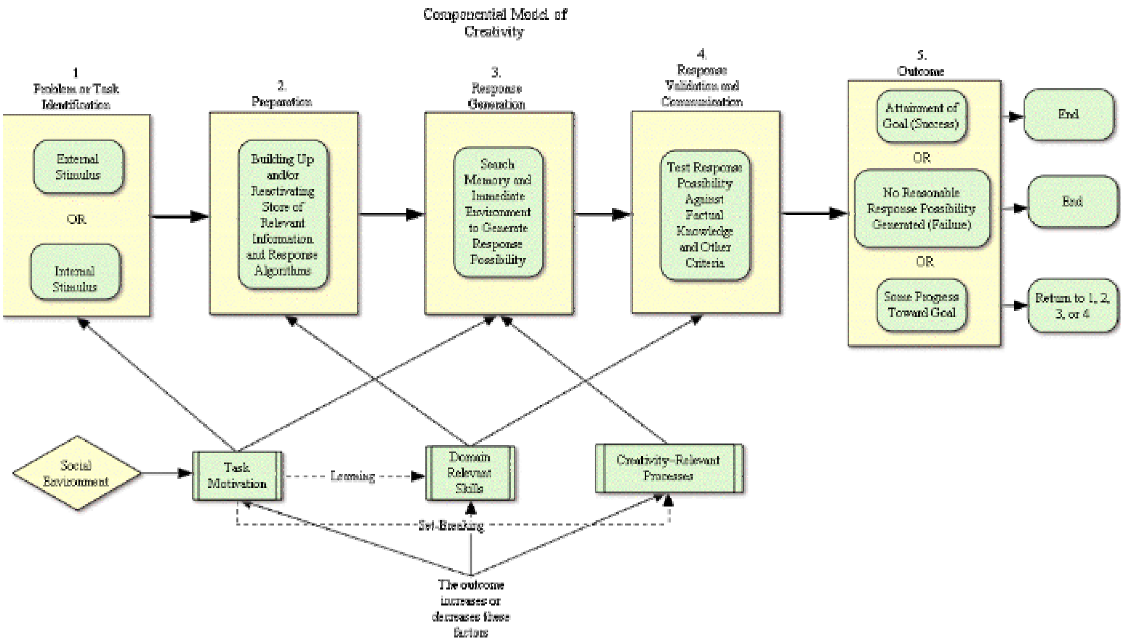


Figure 1. Amabile's componential model of creativity.

In Amabile's model, we can see that innovation starts with some sort of stimulus to innovation. While the stimulus can be internal or external, it usually has strong relevance to the innovator for them to start to work on it. Second, there is a process of reactivating relevant information (generating ideas about the problem) and at the same time, of building up a store of relevant knowledge–in other words, research. Third comes the process that is usually associated with innovation: the generation of possible responses from individual memory and environmental cues such as other individuals, data sources, etc. Fourth comes the process of validation in which the possible responses are tested against factual knowledge, or tested in real-world conditions. Finally, there is an outcome, an assessment of success, failure, or progress towards success. Note, however, that the process is not all one-way. At the outcome stage, there is the possibility of returning to any other stage in the process, and, in fact, this is common. True innovation is the result of persistent attempts to solve, not only a problem, but the ancillary problems that arise with it. A good case in point can be found in the recent re-invention of the humble screw.

Fahey (2005) describes the process by which engineer Ken LeVey working for the Illinois Tool Works (ITE) produced the first real improvement in screw technology since Archimedes first description over 2,000 ago.

In trying to create new markets for the company's products, LeVey realized that there would be a large market if concrete screws, physically arduous to work with, could be made easier to work with. He began by looking at other tools that worked with concrete, and looked carefully at a concrete chisel. He realized, the flash of inspiration, that the chisel put a different stress on the concrete than the screw did, and that if a screw could be made to work more like a chisel, it would be easier to use. He decided that the threads of the screw had to work more like a chisel than conventional screw threads. When he first proposed this idea to colleagues, he was laughed at. After all, it required a new manufacturing technique for making screws to be developed–sustained work with the idea. He assembled a team of interns who put everything known about screws into software, and then played around with ideas. A new technique ensued, and the company now makes an additional U.S.$400 million per year by selling the screws that nobody thought could be made. Figure 2 shows the screw with the chisel-like threads.

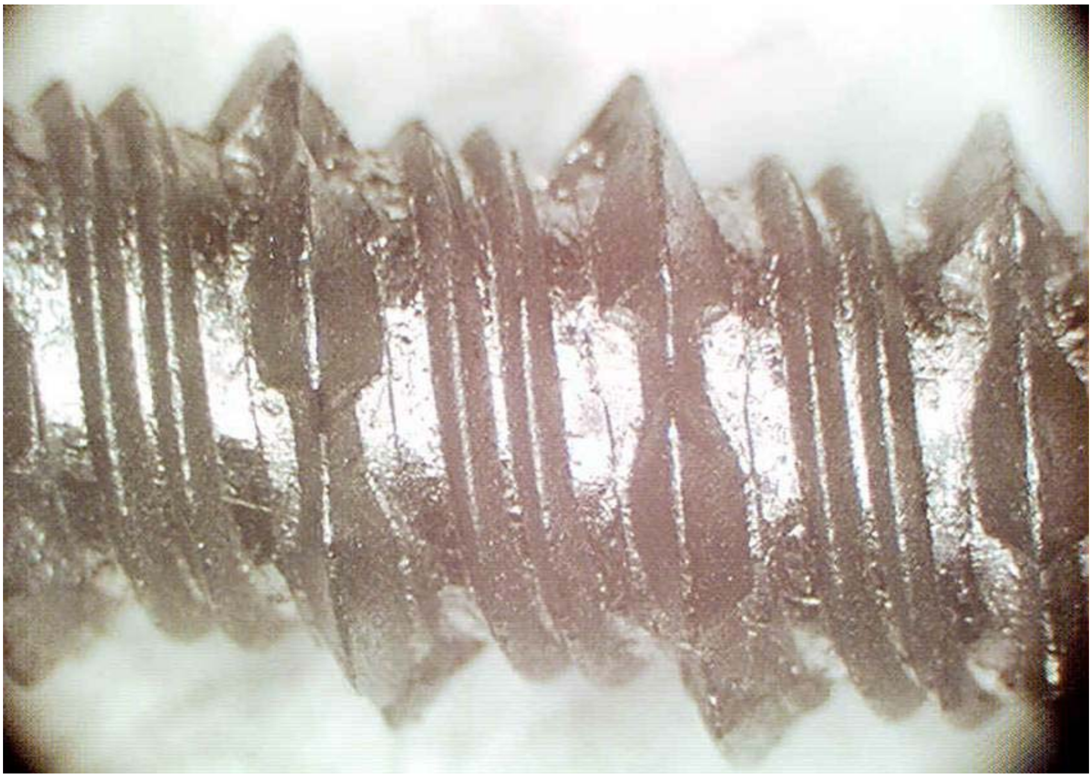


Figure 2. The ITW Tapcon concrete screw with the chisel-like threads.

The story of the Tapcon screw illustrates a number of features of innovation. First, there was the motivation for solving the problem–in this case, selling more screws. Second, there was a period where everything known about screws and the problem were established. Third, there was the synthesis of two different ideas: the screw and the chisel. Fourth, there was the establishment of the team (interns) to create the software needed to explore the possibilities arising from the new idea. Fifth, there was a sustained work stage during which a new process for manufacturing the new type of screw was developed. Finally, there was a validation stage during which the new process was proven to work and have a market.

So although the process sounds simple–put together the idea of a screw thread and a chisel–to actually make it required a sustained effort from a team over a prolonged period.

Education for Innovation

There is an increasing concern in modern industrial societies with the rapid changes brought about by our entry into the Knowledge Age, which can be dated as starting in 1991 when the U.S. spending on knowledge goods outstripped the spending on industrial goods for the first time (Trilling, 2005). Coupled with the rise of the global economy, there is a concern with how Western societies can remain competitive with the emerging economies epitomized by the BRIC economies (Brazil, Russia, India, and China) in which workers will work for much less than North American workers, and those in other Western democracies (Friedman, 2005; Homer-Dixon, 2006; Uhalde, Strohl, & Simkins, 2006). Uhalde *et al.* (2006) suggest the strategy proposed for most industrialized economies: improve the level of educational attainment and quality, and to nurture and unleash the innovative capabilities of their populations. These concerns are echoed by others, (Carter, 2005; Friedman, 2005; Gosselin, 2006; Stanley, 2006-2007), and many more. This provides two imperatives for education in the 21st century: higher standards, meaning that more people have to progress farther in the educational system than ever before; and that they have to be educated for a society of innovation and knowledge creation rather an industrial age society. The educational system must face these challenges. But how is this to be accomplished?

Knowledge Building and Education for Innovation

We must start as we mean to finish. If we want students to be able to function effectively in a culture of innovation, then we must educate them for it starting at an early age. Bereiter (2002) notes the folly of expecting an Industrial Age educational system that places great emphasis on explicit knowledge and on structured solutions to well-known problems to start producing innovators. Creativity, like any other skill, takes practice, and most can achieve some degree of success at it (Amabile, 1996). One of the best current models of education for innovation is Bereiter and Scardamalia's Knowledge Building (KB) theory (Austin, 2002; Bereiter, 2002; Chan, Lee, & van Aalst, 2001; Hewitt, 1996; Scardamalia & Bereiter, 2003).

In knowledge building, students start with a problem of understanding, and proceed through a process of continuous inquiry to progressively deepen their understanding of the problem and generate new solutions to it. Learning in the traditional sense is a by-product of the knowledge building process, which aims to generate new knowledge. This process is aided by the use of the Knowledge Forum software package, groupware designed to support and facilitate the knowledge building process. As with any other theory, Knowledge Building theory and practice can be improved, and in an ongoing effort to do so, the *Knowledge Society Network* has been created.

The Knowledge Society Network–A Network of Networks

Social Networks

A social network forms when individuals interact with one another. Jansson (1999, p. 339) gives this definition: "A social network consists of a group of individuals and the sociometric choices between these individuals." The term *sociometric* here has broad implications: interactions can be measured, and meaningful data can be extracted from these measurements. Granovetter notes (1990, p. 15), "... that no part of social life can be properly analyzed without seeing how it is fundamentally embedded in networks of social relations." Thus, to understand social relationships is to understand the networks that form as these relationships are established and deepened.

Currently, our knowledge about social networks is largely empirical. The *Committee for*

Network Science for Future Army Applications notes (2005, p. 14),

> The current state of knowledge about network design and characterization is roughly analogous to the state of knowledge about metallurgy in Europe in the 16th century. The empirical steel-forming technology of the day was sufficiently advanced to enable Europe to conquer most of the world but provided only a pale indication of the materials designs that would become possible in the 20th century based on the science of metallurgy (Diamond, 1999).

Nonetheless, great strides have been made in recent years, made possible by the increasing power of microcomputers that put powerful network analysis tools into the hands of researchers (Benta, 2002; Borgatti, Everett, & Freeman, 2002; Cyram, 2007). Through the use of these tools, researchers mine data for previously unknown details about the interactions among network members, and how these influence things like innovation (Gloor, 2006). Against this background we now introduce the *Knowledge Society Network*.

The Knowledge Society Network

Arguably the main challenge for 21st century education is to initiate students into a knowledge-creating culture. The Knowledge Society Network (KSN) was created as a design experiment that aims to maximize society's innovative capacity by taking advantage of new knowledge media. The KSN's educational thrust is toward meeting this challenge by immersing even very young students in environments where their main job is knowledge creation (with learning as a by-product). A different but equally challenging effort is bringing knowledge building into the work lives of professional groups (e.g., teachers, bankers, and health care practitioners) who see their job as delivery of quality service rather than advancing the state of the art. Accordingly, much of KSN's work has focused on what it means to create knowledge in these less obvious contexts and how knowledge building can succeed in such contexts, where other sorts of demands are usually paramount. Broadly speaking, the shared goal of KSN participants is to advance knowledge building theory, pedagogy, technology, and practical know-how on enough fronts that it can make a difference to give all citizens a chance to be productive members of a knowledge society.

Characteristics of the KSN

The KSN, as noted, is a network of researchers, but since networks are ubiquitous in society, what is distinctive about the KSN? The following points offer a partial answer (Hong, Scardamalia, & Zhang, 2007):

(1) *Interdisciplinary*: The KSN represents a multidisciplinary mix of the knowledge, information, and learning sciences. The learning sciences were founded in recent years and were defined from the beginning as being interdisciplinary, and they continue to expand to include additional relevant disciplines. Largely through initiatives of the U.S. National Science Foundation, neuroscience has come to play an important (in some laboratories, dominant) role in the Science of Learning Centers. Although the KSN includes one brain research group doing notable research related to cognitive development and learning, it is distinguished by embracing an emerging discipline relatively neglected in the U.S. initiatives: the "knowledge" sciences. "Knowledge science" originated in the context of artificial intelligence and knowledge engineering and was primarily concerned with knowledge acquisition—gaining usable access to what people know (Gaines & Boose, 1988). Since then, interest has grown in knowledge creation as a theoretical problem (Bereiter, 2002; Dennett, 1995), a cultural imperative (Homer-Dixon,

2000), a practical objective (Nonaka & Takeuchi, 1995; Wickramasinghe, 2006), and a locus of socio-political controversy (Pestre, 2003);

(2) *Size and international scope:* With approximately 400 active participants, the KSN is considerably larger than other research-oriented networks in the field. Moreover, the KSN reflects its worldwide membership in its day-to-day activities, bringing an international perspective from more than 20 nations to bear on core problems;

(3) *Inclusion of practitioners:* Most research groups can claim to have close working relations with practitioners. Nevertheless, a "conveyor belt" model still characterizes most groups: New knowledge originates with researchers and problems of application are worked out in collaboration with practitioners. By contrast, in the KSN, teachers and even young students produce research and innovations and present them at scholarly meetings; and

(4) *Conceptual basis:* The core concept that has unified and given direction to work of the KSN is the *knowledge building* theory discussed above. The term "knowledge building," which, in a recent search, appeared in 1,400,000 Web documents, has become important in much broader contexts than the original school context. The competitive demands of a knowledge-based economy and the complexity of urgent societal problems (noted above) converge on a need to greatly enhance knowledge building capabilities.

Self-Organizing Networks

Recent years have seen the rise of what is being called a "new science," called variously *chaos theory*, *complexity theory*, the theory of *self-organizing systems*, the theory of *complex adaptive systems*, and *autopoietic systems* (Gleick, 1987; Kauffman, 1995; Waldrop, 1992). Such systems are characterized by self-organization, a concept that can be initially confusing. Using the term autopoiesis, Combs (1995) defines self-organizing systems:

> Autopoietic systems do not simply maintain stasis in the face of changing external conditions; they dynamically recreate themselves. ... [S]uch systems are best thought of in terms of patterns of processes rather than as material structures, the substance of which may be left behind (p. 27).

Figure 3 shows a simple example of such a system: a small parkette near OISE/UT, in which the traces of the patterns of interactions of people with the grass have left traces of those interactions.

Figure 3. Image of the OISE/UT parkette showing the paths created through human interactions with the grass.

Self-organization can be initially confusing, and *Figure 3* serves to de-mystify it, as self-organizing systems are rather common and ordinary. Each individual who uses the parkette chooses their own trajectory through it, but some destinations are more common than others. Thus there is a path formed by the interactions of many feet from the nearest exit from OISE to a popular sandwich shop. There is a second smaller path from a nearby parking lot to the street. It's as simple as that. There are a limited number of exits from OISE, and only one is near both the parkette and the sandwich shop. These two constraints are enough to create the self-organized path. No one has to tell people to use that exit, nor is the location of the sandwich shop published within the building. Nonetheless, people notice both things, and for very similar reasons, choose this route. Through many, many interactions with the grass of the park, a clear path forms.

In recent years, in order to explain aspects of self-organization at the systems level, researchers have turned to the study of network dynamics (White, 2003). These provide researches with the ability to create visualizations and establish metrics of network dynamics as a way of better understanding interaction patterns among individuals in the system. When the system is a human one, the study of the networks is called *social network analysis* (SNA). Using SNA, researchers can establish the network of interactions among people as they go about their daily activities, including activities resulting in the creation of new knowledge. Tracking these interactions is made easier when an online environment such as Knowledge Forum is used, as the use of server log data allow researchers to record such interactions as note creation, note reading, responding (building-on,) and so forth. Since the KSN uses Knowledge Forum as their locus of interaction, these interactions can be tracked and analyzed.

Self-Organizing Knowledge Networks

Technologies are increasingly created by self-organizing knowledge worker teams (Rycroft, 2003)(Gloor, 2006; Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). For example, Linux is developed by an essentially volunteer, self-organizing community of thousands of programmers who collaborate on diversified ideas through constant exchange of open source code (Evans & Wolf, 2005). The internet itself has also been considered as the single largest network system that self-organizes (Fuchs, 2005), and arguably, internet-based collectives hold promise for increasing society's ingenuity through less hierarchical and more distributed, opportunistic, and global configurations, with potential for greatly increasing idea productivity (Homer-Dixon, 2006). Accordingly, there is an increasing trend to design self-organizing innovation networks (Rycroft, 2003), whether Internet-based or not.

According to Prehofer and Bettstetter (2005), a system must consist of the following features to be considered self-organizing: (1) It is composed of individual entities and has a certain structure and functionality; (2) it is organized without external, central dedicated control. The individual entities interact directly with each other in a distributed peer-to-peer fashion; (3) the application of simple behavior at the microscopic level leads to sophisticated organization at the macroscopic level; (4) it is characteristic of adaptability with respect to changes in the system.

We argue that the KSN is designed as a self-organizing network, corresponding to the above four features: (1) First, the KSN is composed of individuals, and knowledge-building theory and Knowledge Forum, a software program designed to support knowledge-building practice, provides the interaction space. Knowledge building, which can be defined as a social process, provides the structure and functionality. As noted above, knowledge building is a social process that creates a community for the improvement of ideas of value to a community (Scardamalia & Bereiter, 2003). At its simplest level of network complexity, Knowledge Forum serves as a platform for idea generation and improvement. *Figure 4* shows some selected interface design features of a knowledge building *note* to illustrate this point.

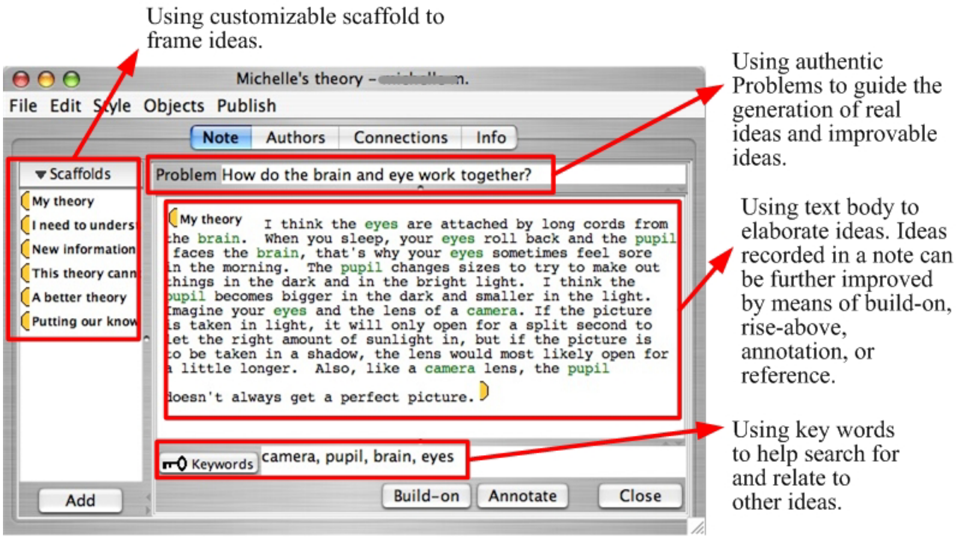


Figure 4. Some Selected Design Features in Relation to Idea Generation and improvement

Knowledge building takes an idea-centered approach to knowledge innovation, and ideas in the objective sense are regarded as shared constructs around which intelligent communities are built (Bereiter, 2002). Such objects have a philosophical dimension described by Lévy (1998), "We can recognize the object by its power to serve as a catalyst in forming social relations and inducing collective intelligence" (p. 156). Therefore, the determination of the structure and functionality of the KSN is fundamentally based on the relationships between the individuals and the objects (ideas)–how agents collaborate with one another to generate and improve ideas.

(2) The KSN is organized without external, central dedicated control, and at the microscopic level, agents and ideas interact with each other in a distributed fashion. As *Figure 5* shows, members in the KSN collaborate in an opportunistic manner based on emergent research interests, and the universal goal of all members is to advance knowledge in relation to knowledge-building theory, pedagogy, and technology. In the KSN, all ideas are treated as public objects that can be continually improved once they are generated and recorded in a Knowledge Forum database (a public space). As noted by Lévy (1998),

> Scientific inventiveness consists in bringing genuine objects into view, the vectors of intelligent communities, capable of interesting other groups who will in turn circulate, enrich, transform, indeed multiply, the initial object and thus transform their identity within the community (p. 158-159).

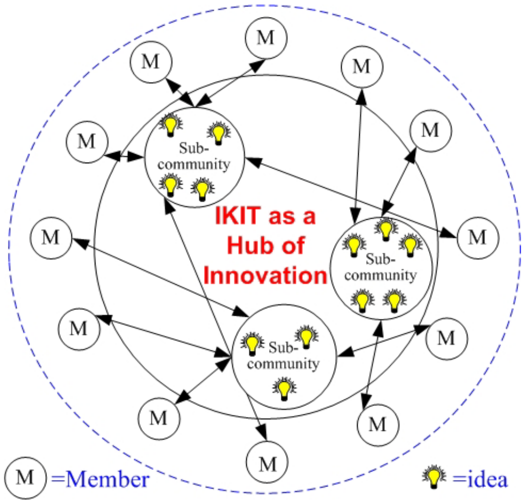


Figure 5. Distributed knowledge interaction in the KSN with opportunistic collaborations around various emerging research ideas being pursued by its members in a self-organizing manner.

(3) The whole network system is governed by a set of knowledge-building principles (see Scardamalia, 2002, for a detailed elaboration). The principles serve as rules in guiding the behavior of individual entities at the microscopic level. Table 1 summarizes the gist of these principles. KSN Members as individual entities then follow the guidance of these principle-based behaviors and this eventually leads the KSN to becoming a sophisticated knowledge-creating community, which distinguishes it from other networked communities.

Table 1.

Knowledge Building Principles

Principles	**Descriptions**
Real Ideas, Authentic Problems	Knowledge problems arise from efforts to understand the world. Ideas produced or appropriated are as real as things touched and felt. Problems are ones that learners really care about—usually very different from textbook problems and puzzles.

Improvable Ideas	All ideas are treated as improvable. Participants work continuously to improve the quality, coherence, and utility of ideas. For such work to prosper, the culture must be one of psychological safety, so that people feel safe in taking risks—revealing ignorance, voicing half-baked notions, giving and receiving criticism.
Idea Diversity	Idea diversity is essential to the development of knowledge advancement, just as biodiversity is essential to the success of an ecosystem. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it. Idea diversity creates a rich environment for ideas to evolve into new and more refined forms.
Epistemic Agency	Participants set forth their ideas and negotiate a fit between personal ideas and ideas of others, using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them. They deal with problems of goals, motivation, evaluation, and long-range planning that are normally left to teachers or managers.
Community Knowledge, Collective Responsibility	Contributions to shared, top-level goals of the organization are prized and rewarded as much as individual achievements. Team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community.
Democratizing Knowledge	All participants are legitimate contributors to the shared goals of the community; all take pride in knowledge advances achieved by the group. The diversity and divisional differences represented in any organization do not lead to separations along knowledge have/have-not or innovator/non-innovator lines. All are empowered to engage in knowledge innovation.
Symmetric Knowledge Advance	Expertise is distributed within and between communities. Symmetry in knowledge advancement results from knowledge exchange and from the fact that

	to give knowledge is to get knowledge.
Pervasive Knowledge Building	Knowledge building is not confined to particular occasions or subjects but pervades mental life—in and out of school.
Constructive Uses Of Authoritative Sources	To know a discipline is to be in touch with the present state and growing edge of knowledge in the field. This requires respect and understanding of authoritative sources, combined with a critical stance toward them.
Knowledge Building Discourse	The discourse of knowledge building communities results in more than the sharing of knowledge; the knowledge itself is refined and transformed through the discursive practices of the community—practices that have the advancement of knowledge as their explicit goal.
Embedded, Concurrent and Transformative Assessment	Assessment is part of the effort to advance knowledge—it is used to identify problems as the work proceeds and is embedded in the day-to-day workings of the organization. The community engages in its own internal assessment, which is both more fine-tuned and rigorous than external assessment, and serves to ensure that the community's work will exceed the expectations of external assessors.
Rise Above	Creative knowledge building entails working toward more inclusive principles and higher-level formulations of problems. It means learning to work with diversity, complexity and messiness, and out of that achieve new syntheses. By moving to higher planes of understanding knowledge builders transcend trivialities and oversimplifications and move beyond current best practices.

(4) At the macroscopic level, the KSN is essentially designed to be an inclusive network-of-networks with a socially scalable structure and a technologically adaptive functionality that allow the whole network system to continuously grow and adapt to changing needs (see Table 2).

The socially scalable structure of the KSN can be illustrated by *Figure 6* that shows two kinds of social configuration as observed in the KSN. One is the core collaboration network, which represents a strongly-interacting collaboration community, and the other is a peripheral collaboration network which accommodates many small emerging communities.

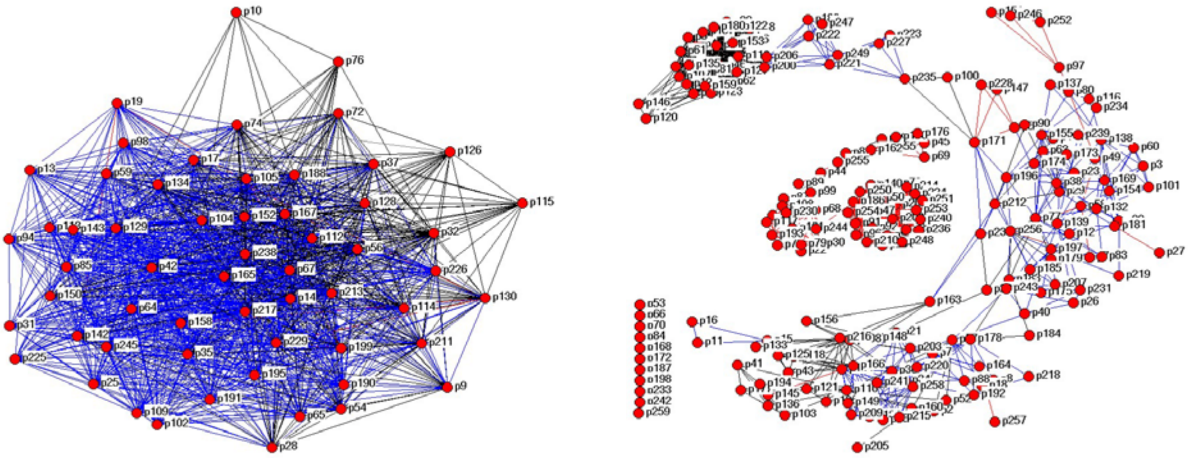
In terms of its technological infrastructure, the KSN is a meta-database that serves as a coordinating structure—a hub of innovation to coordinate each sub-group or community. But due to its international scope, a substantial amount of the work of the KSN is still carried out online (i.e., technology based). The KSN is thus adaptable in that, from a local perspective, each sub-group or community of the KSN is a single and unique network, but from a global perspective, the KSN is also designed to be a knowledge building network-of-networks—or as we prefer, community-of-communities.

Table 2.

Cumulative Growth in the KSN (2002-2005)

	Year1	Year2	Year3	Year4(2005)
Number of contributors	10	116	213	274
Number of views	13	55	135	172
Number of readers	47	200	290	353
Number of notes contributed	67	1042	3868	4472
Ratio of contributors over readers*	0.21	0.58	0.73	0.78

* Contributors must be readers but readers are not necessarily contributors.



6a: Strongly-Interacting Pattern 6b: Weakly-Interacting Pattern

Figure 6. Network Patterns of Collaboration in the KSN. In both figures, each red-circled-node represents a contributor and each tie represents at least one view in which two contributors collaborate together. Colors of lines refer to years: year 1 (green), year 2 (black), year 3 (blue), and year 4 (red). The year 1 ties (green) are too few to be seen in both figures.

Discussion

A main interest of this paper is to find out whether the KSN can be regarded as a self-organizing network and how to further improve its design accordingly for sustained knowledge innovation. A careful comparison against the common design features of self-organizing networks characterized by recent literatures has suggested that the KSN was indeed designed as close as it can be to be a self-organizing knowledge network. The next question to ask is how to further improve the KSN.

One way for further improvement may be to extent KSN members' social metacognitive capacity, that is, knowledge of other members' knowledge, or "people knowledge" (Hong, 2005; Hong & Lin, 2005). Arguably, to advance knowledge in any networks, especially larger ones, it is crucial for members to know who's working on what ideas and advancing what cutting-edge knowledge, so that a more reflective, dynamic, and opportunistic kind of collaboration in a network can be facilitated and supported at all time.

To expand this possibility, our research team is currently adding new design features into Knowledge Forum, which include the development of a suite of new assessment tools. One of these new tools is the Social Network Analysis Tool, which enables members to freely explore existing collaboration patterns among members (who links with whom) in the KSN (Philip, 2007). Another tool is the Semantic Analysis Tool (Teplovs, 2005), which allows members to explore knowledge-interaction patterns between views (e.g., what ideas relate to what ideas) in the KSN. At an microscopic level, the tools are designed to extend members' social metacognitive capacity and to support epistemic agency (Russell, 2002; Scardamalia, 2002) for more effective knowledge building initiated by the members themselves. These new tools should allow members to monitor and reflect more often on who has worked on which ideas (or sets of ideas), so members share a meta-perspective on their work. More effectively distributed knowledge building processes should result (Hewitt & Scardamalia, 1998). Arguably, for any knowledge networks where knowledge innovation rather than knowledge reproduction or accumulation is considered as their most important goal, there will be no recipes, formula, or specifiable directions to guide the course of its knowledge creation. The optimal course towards knowledge innovation will be a self-organizing one. Whether the new technology design as described above would add value to this process, however, remains an empirical question to be answered.

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