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The fallacy of knowledge reuse: Building sustainable knowledge[1]

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Abstract

Purpose—*Based on recent neuroscience research, and a deeper understanding of information and knowledge, this paper investigates the characteristics of building sustainable knowledge for communities and cities with a focus on the social process of knowledge mobilization.*

Design/methodology/approach— *This paper explores the concept of knowledge reuse by (1) providing a new model of information and knowledge consistent with neuroscience and the demands of CUCA, (2) using this model as an analogy to explore the social context of knowledge mobilization with its process of collaborative entanglement, and (3) looking at the concepts of knowledge robustness and sustainability from the viewpoints of individuals and the community.*

Findings— *Knowledge mobilization is modeled after the associative network of neuronal firings in the human brain. The process of collaborative entanglement among experts and stakeholders not only helps provide specific solutions to current issues, but seeds the ground for continuous community improvement, collaboration, and sustainability.*

Practical implications—*Provides practical ideas and techniques for communities and individuals to move toward knowledge sustainability.*

Originality/value—*Develops a new frame of reference for looking at social knowledge mobilization and knowledge sustainability.*

Keywords *knowledge sustainability, knowledge reuse, knowledge mobilization, knowledge robustness, brain, complex adaptive system*

Paper type *Conceptual paper*

Introduction

In a little over 30 years, Singapore raised its annual per capita income from $1,000 to $30,000 (Yew, 2000), and by 2007 Singapore was recognized as having the second highest per capita income in the world. In October of 2007 Singapore was named The Most Admired Knowledge City (The World Capital Institute and Teleos, 2007). Singapore was perceived by a panel of experts as the world winner based on their identity, intelligence and financial capital, all largely built on Singapore's ability to identify, transfer and apply the best knowledge from around the world. In just two years, the number of annual U.S. tax returns prepared in India jumped from 100,000 to

[1] Release of *Knowledge Mobilization in the Social Sciences and Humanities: Moving from Research to Action* (MQIPress, 2007) occurred in concert with the first Knowledge Cities Forum held in Monterrey Mexico in October 2007. This paper does not repeat that extensive treatment. Rather, it looks at the knowledge mobilization process as an analogy to the workings of the brain.

400,000 (Friedman, 2005), serving as an example of the international flavor of knowledge work making its way around the world from the U.S. into the economic life of India. Over the last eight years, the number of Americans using their knowledge to work from home has doubled to represent 16 percent of the U.S. workforce (Friedman, 2005). In the midst of what might be called a knowledge millennium, organizations, communities, cities and nations are hungry for knowledge and the potential advantages it offers towards sustainability and a higher quality of life.

No matter what the venue, there are two approaches to increasing knowledge capacity and capability: either bring it in from the outside or grow it from the inside. Bringing it in from the outside might include buying information, hiring experts, benchmarking and/or adopting and adapting best practices. When efficiency was the defining factor of success in the 20th century, the attempted transfer of best practices flourished. As long as a best practice was relatively simple and dealt with a repetitive process—and the environments of the organizations or communities involved were similar and fairly stable—a successful transfer *was possible*. However, since best practices focus on actions and often neglect the level of understanding and insight into the *how* and *why* things actually work, they were often ineffective in *differing* situations and contexts (Brown and Duguid, 2000).

As we enter the 21st century, the explosion of information coupled with global connectivity is creating a future filled with change, uncertainty and increasing complexity[2], a future that is best understood as accelerating towards us (Bennet and Bennet, 2004). While best practices may be indicators of past needs and capabilities that worked in specific situations, best practices are typically not robust or adaptable. Since we (1) are all facing *new* challenges, (2) cannot do things the way we've done them in the past, and (3) may not be able to use best practices from others, where *will* we get the new knowledge necessary for success?

As introduced in the best practices example above, all too often we look to the past for answers. This paper explores the concept of knowledge reuse through (1) providing a new model of information and knowledge consistent with neuroscience and the demands of CUCA, (2) using that model as an analogy to explore the social context of knowledge mobilization with its process of collaborative entanglement, and (3) looking at the concepts of knowledge robustness and sustainability from the viewpoints of individuals and the community. We begin.

Differentiating Knowledge

Embracing Stonier's description of information as a basic property of the Universe—as fundamental as matter and energy (Stonier, 1990; Stonier, 1997)—we take the amount of information to be a measure of the degree of organization expressed by any non-random pattern or set of patterns. The order of a system is a reflection of the

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[2] CUCA is a term coined in *Organizational Survival in the New World: The Intelligent Complex Adaptive System* (Elsevier, 2004) to represent increasing **C**hange, rising **U**ncertainty, growing **C**omplexity, and the **A**nxiety as people become entangled within this environment.

information content of the system. Data (a form of information) would then be simple patterns, and while data and information would both be patterns, they would have no meaning until some organism recognized and interpreted the patterns (Bennet and Bennet, 2008c). Thus knowledge exists in the human brain in the form of stored or expressed neuronal patterns that may be activated and reflected upon through conscious thought. This is a high-level description of the creation of knowledge that is consistent with the neuronal operation of the brain and is applicable in varying degrees to all living organisms. From this process neuronal patterns are created that may represent understanding, meaning and the capacity to anticipate (to various degrees) the results of potential actions. Thus it is not just information that defines knowledge, but the relationships or associations (in space and time) among that information. Through this process of associating (or complexing), the mind is continuously growing, restructuring and creating increased organization (information).

Taking a functional approach, our definition of knowledge then becomes: *knowledge is the capacity (potential or actual) to take effective action in varied and uncertain situations* (Bennet & Bennet, 2004). Knowledge consists of comprehension, understanding, insights, meaning and the ability to anticipate the effect of our actions. Knowledge is neither true nor false and its value is difficult to measure other than by the results of its actions. Hence, good knowledge would have a high probability (P=.9) of producing the desired (anticipated) outcome, and relatively poor knowledge would have a low probability (P=.1) of producing the expected result. It should also be understood that desired outcomes cannot usually be described with high precision. Rather, there is likely to be a cone of acceptable outcomes that have different measures of goodness (see Figure 1). Of course, any attempt to measure the value of specific knowledge may be quite difficult due to its dependency on situational context (discussed later in this paper).

This definition of knowledge highlights knowledge as a creation of the human mind. The term knowledge is often used in organizations, popular literature, and technology solutions to mean the same thing as "information." Recognizing that knowledge is the result of associative patterning in the brain, we choose to consider knowledge as comprised of two parts: Knowledge (Informing) and Knowledge (Proceeding). This builds on the distinction made by Ryle (1949) between "knowing that" and "knowing how".

Knowledge (Informing), or $Kn_{I,}$ is the *information (or content)* part of knowledge. While this information part of knowledge is still generically information (organized patterns), it is special because of its structure and relationships with other information. Kn_I consists of information that represents insights, meaning, understanding, expectations, theories and principles that support or lead to effective action. When viewed separately this is information that *may* lead to effective action. However, it is considered knowledge when it is used as *part of the knowledge process*. Note that when "knowledge" is described and stored in a database or book, only the information part of that knowledge is stored, often considered as knowledge artifacts (Stankosky, 2005).

Knowledge (Proceeding), Kn_P, represents the *process* and *action* part of knowledge. Kn_P is the process of selecting and associating and applying the relevant information (Kn_I) from which specific actions can be identified and implemented, that is, actions that result in some level of effective outcome. There is considerable precedence for considering knowledge as a process versus an outcome. As Kolb (1983) forwards in his theory of experiential learning, knowledge retrieval, creation and application requires engaging knowledge as a process, not a product. The process our minds use to find, create and semantically mix the information needed to take effective action is often unconscious and difficult to communicate to someone else. The more complex a situation, the more difficult to find a solution, and the larger the role played by tacit knowledge in our unconscious mind (Goldberg, 2005; Bennet and Bennet, 2008b).

Tacit knowledge (Kn_t) is the descriptive term for those connections among thoughts (neuronal patterns) that cannot be put into words. It is a knowing of *what* decision to make or *how* to do something that cannot be clearly voiced in a manner such that another person could extract and re-create that knowledge. An individual *may or may not* know they have tacit knowledge in relationship to something or someone. But even when you know you have this knowledge you are unable to put it into words or visuals that can convey it. To "convey" is to cause something to be known or understood or, in this usage, to transfer information in a manner such that the receiver is able to re-create the intended knowledge. In contrast, *explicit knowledge* (Kn_e) is the process of calling up information (patterns) and processes (patterns in time) from memory that can be described accurately in words and/or visuals (representations) such that another person can comprehend and re-create that knowledge. This has historically been called declarative knowledge (Anderson, 1983). We use the term *implicit knowledge* (Kn_i) to refer to knowledge stored in memory of which the individual is *not immediately aware.* While this knowledge is *not accessible on demand*, it may be pulled up when triggered (associated). In other words, implicit knowledge is knowledge that the individual *does not know* they have, but is self-discoverable! Implicit represents a mobile spectrum between explicit and tacit. For a more extensive treatment of this concept see Bennet and Bennet (2008b).

There are four aspects of tacit knowledge: embodied, intuitive, affective, and spiritual (Bennet and Bennet, 2008b; Merriam, et al, 2006). Embodied tacit knowledge (both kinesthetic and sensory) is knowledge represented in material form stored within the body. Intuitive tacit knowledge is a sense of knowing based on life experiences, "the mysterious mechanism by which we arrive at the solution of a problem without reasoning toward it" (Damasio, 1994, p. 188). Affective tacit knowledge represents *feelings* that are not expressed—perhaps not even recognized. Spiritual tacit knowledge is a form of higher guidance with unknown origin, providing a transcendent frame of reference that puts things in relationship to a larger perspective while promoting self-knowledge and learning (Bennet and Bennet, 2008b).

Sustainable knowledge is considered as knowledge that is robust enough to handle some level of variability within its domain of action and can be dynamically modulated to handle large-scale changes, uncertainties or increasing complexities within that domain.

The Fallacy of Reuse

The fallacy of knowledge reuse is addressed from several viewpoints. First, in terms of knowledge as context-sensitive and situation dependent. Second, in terms of how information is stored in and re-created by the brain. The explosion mentioned in the opening paragraphs of this paper was a reference to *information*, which may or may not have been used in a specific situation or context as a part of knowledge (as knowledge artifacts). Recall that knowledge is differentiated from other information in that knowledge contains information that supports the capacity to take effective action. Thus knowledge relates not only to its information content (Kn_I) but also to the efficacy of that information content *in terms of the situation at hand* (Kn_P).

The innate ability to evoke meaning through understanding—to evaluate, judge and decide—is what distinguishes the human mind from other life forms. This ability enables us to discriminate and discern—to see similarities and differences, comprehend and form patterns from particulars, and purposefully create, store and apply knowledge. In this human process of creating meaning and understanding from external stimuli, *context shapes content* (Bennet and Bennet, 2007a). The word "context" comes from the Latin stem of *contexere* which translates as "weave together." Today we recognize that all knowledge, to varying degrees, is context-sensitive and situation dependent (there are no impenetrable boundaries). This means that while the content may be constant, when you change the context the meaning of the content in that new context can be entirely different. The greater the complexity of a situation, the greater the potential number of patterns and relationships of patterns that make knowledge relevant to that situation, and the less likely that knowledge would apply to different situations.

Pragmatic knowledge draws directly on the lessons of past hands-on experiences *within specific circumstances* to determine how things actually work. Pragmatic knowledge is knowledge focused toward action because it is *continuously customized and improved* by close observation of the effectiveness of those actions in meeting expected results. This is earned knowledge, a "knowing" that individuals—and by extension the organizations with which they are associated—have built through experience, reflection and comprehension of how to interpret situations and what actions to take to achieve desired outcomes. This pragmatic way of knowing helps interpret relationships difficult to recognize, that is, those that exist between *how* we see a situation (our frame of reference) and *what rules we use* to determine our actions. Pragmatic knowledge can be closely linked to the capacity of community members to learn from their own experiences. From this perspective, knowledge arises through interacting individuals as they reflect, experiment, and identify new ways of doing things in their communities. Pragmatic knowledge creation is then primarily a matter of learning through actions, feedback and day-to-day conversations with others, and secondarily through internal discovery and inquiry.

The Representation of Thought in the Brain

In the brain thoughts are represented by patterns of neuronal firings, their synaptic connections and the strengths between the synaptic spaces. For example, a single thought could be represented in the brain by a network of a million neurons, with each neuron connecting to 5,000 other neurons. Incoming external information (new information) is mixed, or semantically complexed, with internal information, creating new neuronal patterns that may represent understanding, meaning, and/or the anticipation of the consequences of actions, in other words, knowledge. The term *associative patterning* describes this continuous process of learning. From the viewpoint of the mind/brain, any knowledge that is being "re-used" is actually being "re-created", and, in an area of continuing interest, most likely complexed over and over again as incoming information is associated with internal information. Further, if Kn_I is different, there is a good chance that Kn_P will be different, that is, the *process* of pulling up and sequencing associated Kn_I and semantically complexing it with incoming information to make it comprehensible is going to vary. In essence, every time we apply knowledge (Kn_I and Kn_P) it is to some extent new knowledge because the human mind—unlike an information management system—*unconsciously tailors what is emerging as knowledge to the situation at hand*! This is the art of Kn_P. See Edelman (2000) for an enlightening discussion on the non-repeatability of memory recall.

Further, when you see a picture only about 20 percent of what you are seeing is represented in the image in your brain; the other 80 percent of that image comes from information, ideas and feelings already in your brain (Marchese, 1998). While this statement may appear a bit strong, the point that is made is that the mind doesn't store memories like a computer, that is, storing everything that comes in. The mind stores the *core* of the picture, what Hawkins calls an invariant (Hawkins, 2004). This particular phenomenon of relating external and internal forms of experience is called appresentation (Marton and Booth, 1997). As Moon explains,

> Appresentation is the manner in which a part of something that is perceived as an external experience can stimulate a much more complete or richer internal experience of the 'whole' of that thing to be conjured up (Moon, 2004, p. 23).

For example, if you see your friend from the side or back you can usually recognize who they are since your mind has stored a core basic memory that includes major features of that person. When you see your friend, your mind is filling in the blanks and you recognize the incoming picture as your friend. There is efficiency in this process.

Simultaneously, there is robustness in the way the brain *stores* core memories. If it takes a million neurons to create a specific pattern (the core part of incoming information), the brain may set aside 1.4 million neurons with their connections as space for that pattern, providing a looseness to account for future associative changes (or perhaps for dying cells). Thus for this particular pattern you could lose tens of thousands of brain cells and still have significant aspects of the core memory available for future retrieval via re-creation. While this may not appear efficient in terms of energy utilization, from an effectiveness viewpoint it is extremely well-designed. Similarly, network theory espouses the development of repetitive nodes built on a distributed information model, thereby creating redundancy. Similar to neuron signals, the flow *among* nodes becomes essential for success. An example of this is expressed in the network centric warfare which is "more about networking than networks" (DONCIO, 1998).

Knowledge reuse contains the same dangers as those recently recognized by the legal system concerning eye witness testimony. Witness testimony assumes memory recall is stable, accurate and reliable. As introduced above, findings in Neuroscience have indicated that this is not true (Edelman, 2000). Since every time you re-member something you regenerate it, and since you don't store 100 percent of a memory, you can rarely pull anything up exactly as you did previously. The significance of these findings to the legal system is staggering. Moenssens, et al (1995) state that more than 4,250 Americans every year are wrongfully convicted due to inaccurate eyewitness testimony. From their point of view,

> The physical aspects of an event are obviously compromised by the selective nature of the acquisition stage of memory. However, matters are further complicated by the fact that acquisition also involves a social component. Thus, a witness' ability to perceive accurately is affected by both event factors—those inherent to the event itself—and witness factors—those inherent to the witness (Moenssens, et al, 1995, p. 1171).

While our earlier examples dealt with relatively simple situations, as Moenssens, et al, point out, life is not simple. At the same time you catch sight of your friend and are smiling, getting ready to call out and wave, you may be swatting gnats away from your eyes, shivering from a soft breeze, smelling burning rubber from a car that just sped by, registering the dark clouds moving in from the west, feeling hunger pains in your stomach, and sensing a soreness in your little toe due to tight shoes. Etcetera. The brain is multidimensional, simultaneously processing visual, aural, olfactory and kinesthetic sensory inputs and, as discussed above, combining them with mental thoughts and emotional feelings (internal patterns) to create an internal perception and feeling of external awareness (Bennet and Bennet, 2006a). As discussed above, the brain is simultaneously identifying and storing core patterns from incoming information; in other words, there is a hierarchy of knowledge where hierarchy represents "an order of some complexity, in which the elements are distributed along the gradient of importance" (Kuntz, 1968, p. 162). A hierarchy of knowledge is analogous to the physical design of the neocortex, "a sheet of cells the size of a dinner napkin as thick as six business cards, where the connections between various regions give the whole thing a hierarchical structure" (Hawkins, 2004, p. 109).

In a hierarchy the dominant structural element may be a central point such as in a circular structure, or have an axial symmetry. Wherever the central point (dominant structure) is located, each part is determined by where it is located in relation to that central point. While it is true that in a radical version of hierarchy the entire pattern may depend directly on an open center, most hierarchies consist of groups of subordinate hierarchies who in turn have groups of subordinate hierarchies, with each group having its own particular relation to the dominant center point (Kuntz, 1968). The core pattern stored in the brain could be described as a pattern of patterns with possibly both hierarchical and associative relationships to other patterns.

Hierarchical relationships affect the robustness and sustainability of knowledge. Recall the story of the two watchmakers, Hora and Tempus (Simon, 1969). Tempus constructed his watches such that his work fell to pieces every time he was interrupted. Hora designed his watches so that he could put together subassemblies so that when he was interrupted only a portion of his work was lost. Simon calls this a hierarchy of potential stable subassemblies, "Nothing more than survival of the fittest—that is, of the stable" (Simon, 1969, p. 93).

The idea underlying this description is that some semi-independent subcomponents within a complex system will perform specific sub-functions that contribute to the overall functioning of the system (Simon, 1969). Complex adaptive systems are partially ordered systems that unfold and evolve through time and are often constructed in a hierarchy of levels (Bennet and Bennet, 2004; Bennet and Bennet, 2006b). Considering the brain as a semi-independent subcomponent of the body that contains a hierarchy of patterns associated with other patterns, the higher level (core) patterns would retain their associations (in terms of meaning, understanding and anticipation of the future) even as the lower level patterns (internal information that is situation dependent) is re-created in response to new incoming information. A recent study of chess players showed that experts examined the chessboard patterns (not the pieces) over and over again, looking at nuances, generally "playing with" and studying these *patterns* (Ross, 2006). Similarly, an expert in a bounded domain who has developed higher level patterns through years of trial and error in varied situations would most likely use pattern recognition and chunking rather than logic and lower-level relationships as a means of understanding and decision-making.

The above discussion brings home the fact that the mind/brain develops robustness and deep understanding derived from its capacity to use past learning and memories to complete incoming information instead of storing all the details. This provides the ability to create and store higher level patterns while simultaneously semantically complexing incoming information with internal memories, adapting those memories to the situation at hand. Through these processes—and many more that we do not yet understand—the brain supports survival and sustainability in a complex and unpredictable world.

Learning to Mobilize Knowledge in Communities

Biological systems are remarkably smarter in their support of the body than we are in sustaining our work places and communities. Fortunately, we can and are learning from ourselves in this sense, and whether we reflect on this learning in the form of a reality or as an analogy is insignificant as long as we keep learning. For example, consider the social process of knowledge mobilization, with specific focus on the application of university or research findings to the community stakeholder group where they can make a difference for the citizen. For purposes of this discussion, *knowledge mobilization* is the process of generating value or a value stream through the creation, assimilation, leveraging, sharing and application of focused knowledge to a bounded community (Bennet and Bennet, 2007b). In communities and cities this concerns the creating, moving and tailoring of knowledge from its source in universities and individual experts to practitioners, community leaders and larger stakeholder groups such that consequent actions are effective and sustainable.

KMb is a process—or a program comprised of a number of specific processes. The KMb approach taken depends on the timing, application, situation and needs of the community and stakeholders it touches. For a simple problem, the KMb process may end when the problem is solved, but for a more complex problem the process may continue as long as the action sequence is needed to achieve the objective. In a social setting new thoughts and behaviors proposed through research emerge and then build on other thoughts and behaviors from practitioners and then become mixed with yet another set of thoughts and behaviors from the community, and so on. We call this mixing, entwining and set of unpredictable associations the process of *entanglement*. In other words, the knowledge mobilization process in a community—moving bounded theoretical knowledge into the community—works very much as does the human mind.

Collaborative entanglement consistently develops and supports approaches and processes that combine the sources of knowledge and the beneficiaries of that knowledge to interactively move toward a common direction such as meeting an identified community need. Beyond decision-making, collaborative entanglement includes the execution and actions that build value for all stakeholders, engaging social responsibility and providing a platform for knowledge mobilization. The collaborative entanglement model is highly participative, with permeable and porous (unclear and continuously reshaping) boundaries between the knowledge researcher and knowledge beneficiary as well as between the research and application of the research. In other words, the research itself becomes part of the process of implementing research results (Bennet and Bennet, 2007b). Lee and Garvin contend that to be effective, knowledge exchange depends on multi-directional, participatory communication among stakeholders (Lee and Garvin, 2003). *The collaborative entanglement model moves beyond knowledge exchange to the creation of shared understanding resulting in collaborative advantage and value results*. While an in-depth treatment of approaches to collaborative entanglement is not the focus of this paper, these include appreciative inquiry, social marketing, community service-learning, participative inquiry, action research and action learning, as well as other experiential learning techniques (Bennet and Bennet, 2007b).

Collaborative entanglement in terms of a social phenomenon can be analogous to the natural activities of the brain, with the brain representing the researcher and the stakeholder community representing the knowledge beneficiary. All the living and learning of the host human is recorded in the brain, stored among some hundred billion neurons that are continuously moving between firing and idling, creating and re-creating patterns. Information is coming through the senses which, assuming for the sake of our analogy, resonates with patterns that have strong synaptic connections and emotional tags. When resonance occurs, the incoming information is consistent with the individual's frame of reference and belief systems. As this incoming information is complexed (the associative patterning process) it connects with (and to some degree may bring into conscious awareness) deep knowledge. The unconscious continues this process (24/7), with new knowledge (the capacity to take effective action) emerging at the conscious level.

In the collaborative entanglement model, individuals and groups are continuously interacting as new information comes through their sensors: (1) they recognize a problem or issue and/or solution, (2) they see new indicators that bode well or poorly for the community, or (3) new events occur that affect an on-going project or community effort. From these interactions and others—often related to strong emotional feelings which increase the importance and strength of their meaning—new knowledge emerges. When researchers and practitioners are engaged in this interactive, emergent process with other stakeholders, the new knowledge that emerges is *informed* by their learned expertise. As new knowledge is applied and this iterative loop of collective learning continues, a large amount of tacit knowledge (embodied, affective and intuitive) is created beyond that which visibly affects the community. This tacit knowledge then forms the grounding (state-of-the-art thinking) for future incoming information that will be associated with these patterns. In other words, the process of collaborative entanglement among experts and stakeholders not only helps provide a specific solution to a current issue, but seeds the ground for continuous community improvement, collaboration, and sustainability.

A Closer Look at Knowledge Sustainability and Robustness

Knowledge as we have defined it has meaning and is in reference to some domain of action. By domain is meant an area with reasonable boundaries, a sphere of activity or field of concern. For example, for a firefighter the domain is fire and the expertise is putting fires out (perhaps specializing in specific types such as forest fires). Over time a domain of action can be stable, variable (slow or fast), or unpredictable and uncertain. For knowledge to be sustainable, it must maintain its capacity to take effective action even when the nature of the domain changes. For example, if the domain becomes highly dynamic, there is less time to make decisions and the application of knowledge must occur much faster. This means that the best knowledge will consist of immediately available information with the appropriate actions already developed. Previously developed scenario knowledge (an approach used in warfare) might be the only way to survive. On the other hand, if the domain becomes increasingly complex, but slower to change, knowledge of seeding, modeling, pattern detection or sense and response techniques may produce the most effective results (Bennet and Bennet, 2008a).

For a community, a particular domain can be characterized by major factors or characteristics such as: growth rate, nature of culture, economic system, educational level or political structure. If you looked at a small town in West Virginia or the Alps that had not changed much in the last 100 years, you'd have a very stable domain for a decision-maker who had an expertise related to similar environments. A small town water problem could be vastly different than a large city's problems; in fact, the differences may be so great that they could easily fall into different domains. So, in addition to deep knowledge pertinent to a specific domain, an expert would need *specialized* knowledge and experience, much of which could be highly context-sensitive and situation-dependent.

For a more complex and publically visible environment, an expert would need a higher level of awareness and a good understanding of issues *and* politics, that is, a more robust knowledge base. At any point in time, an expert's knowledge would be effective over a certain range of variability within a domain of action. The robustness of that knowledge would involve its strength (quality and depth) and hardiness (breadth and relevance over time). For example, when you first start teaching your daughter to drive a car, you explain the basics to her and take her to an empty parking lot to try it out. As she demonstrates competency, you expand the areas in which she practices driving. Over time her driving ability becomes more robust. She can effectively deal with a broader range of environments and emerging requirements, and a large amount of the knowledge she is building becomes tacit. Even as she is learning "the rules of the road" that you are repeating over and over again in her ear, she is embodying physical knowledge of how to successfully navigate the car in and out of tight situations. Embodied tacit knowledge is built up in all of us as we repeat physical manipulations and/or use our other senses to make judgments and decisions.

As another example, think of an expert golfer whose knowledge is strongly intuitive, embodied and affective but at the same time has to be robust enough to play all the major golf courses in varied weather (temperature, rain, wind, etc.). Compare his knowledge to that of a football quarterback who must play not only in varied weather but with different teammates and against different teams with different plays, all unique. The quarterback's tacit knowledge would have to be considerably more robust than that of a golfer. Both would include elements of spiritual tacit knowledge; the golfer in connecting with the larger aspects of nature, the football player in connecting with his teammates.

People who repeatedly make effective decisions are said to have good knowledge, howbeit that knowledge may only be effective in a specific type of situation. However, higher order patterns help determine the probability of success. An expert who has robust knowledge will be more successful in a dynamic environment than one whose expertise only applies to a narrow band of situations. The higher order patterns discussed earlier, i.e., patterns of patterns that apply to a wide range of situations, provide robust knowledge (Bennet and Bennet, 2006a). These patterns, when they exist, may be recognized by the unconscious mind without any conscious awareness on the part of the expert. This is why highly competent people often cannot explain how or why they know what to do, they just know what needs to be done and how to go about doing it. They consistently demonstrate high quality knowledge. Note that the quality of knowledge is an indicator of the probability of its action yielding the intended effectiveness. While every decision is a guess about the future (Bennet and Bennet, 2004), conceptually there is some degree of probability of success, or quality of knowledge (the capacity to take effective action).

Several dangers come into play for community experts in a specific domain of action. If the domain changes and the expert does not recognize it, then the application of his/her knowledge can fail. On the other hand, the expert may recognize that a situation is different but think that current knowledge will work when, in fact, it will not. Another issue enters at this point. Since individuals typically find what they are looking for, or see what they expect to see, there is a bias to interpret a problem from an historical, proven, and comfortable frame of reference, one that may not recognize the complexities of the current problem. *This produces a bias toward knowledge reuse*. At any single point in time no one can see beyond their threshold of perception (based on a lifetime of living and learning). Another bias toward knowledge reuse arises because of the perception of a "blessed history". The ramifications or loss of face when "tried and true solutions" fail may be considerably less than when new, creative solutions fail. An advantage in looking to the human brain for answers rather than to an information system is that the human brain is more likely to take into account the uniqueness of each situation. Unfortunately, our brains also carry baggage from the past in terms of prejudice; technology has no prejudices, but it never forgets.

The value of the robustness and sustainability of knowledge lies far beyond its impact through experts. If learning comes primarily from the internal complexing of individual lived experience, then most of our knowledge is connected to our experience. If reusing this knowledge is dangerous, how are we to survive in the world? The answer is at once complex and simple. Considering the simple side of that answer, sustainability is not a constant, but rather comes from continuous learning and re-learning—creating, re-creating and adapting knowledge—as we co-evolve with our environment. For our communities and cities, as well as each of us as individuals, the objective is no longer a stable, secure environment. Sustainable communities and cities are those engaged in the continuous process of collaborative entanglement (complexing and associative patterning) and mutual adaptation from which we can learn, grow and thrive.

Answering from the complex perspective, is there a set of actions that can improve the sustainability of knowledge? Perhaps the best way to create a capability for robust knowledge is for a city or community to spawn, foster and encourage diversity, dialogue, open-minded thinking and honest opinion. This allows all major decisions to use—and create—up-to-date, relevant and appropriate knowledge for the long-term effectiveness of actions. Given this approach, key community groups could develop the capacity for efficient, rapid and effective dialogues, problem-solving and decision-making, processes that are particularly appropriate for emergency situations or rapidly changing events within a community. This would include addressing the significant challenge of communicating to citizens (in terms of shared understanding) the need for redirection or changes through knowledge mobilization. For example, if a community has been successfully doing something one way through a local political group and there is a significant political shift at the national level, there will undoubtedly be changes at the state and community levels. The local governing board would not only be responsible for deciding what the right decision is from a knowledge perspective, but would have to also address the social and political issues involved in terms of the larger stakeholder group.

Communities, cities and nations can only be as effective as their constituents. Every decision-maker—which at some level includes every individual in the community—has the responsibility to pursue sustainability in the domains of knowledge they influence or that influence them. This process starts with the active involvement of all community members in knowledge mobilization processes, connecting through whatever ways each individual best learns and can best contribute, whether that means involvement in formal learning processes or spending time reading, reflecting, and engaging in community dialogues and events. Some specific ideas for individuals to create sustainable knowledge are detailed in Table 1.

Final Thoughts

From a neuroscience viewpoint, we quite literally live in an infinite sequence of continuous "now's", and everything else is memory. Yet a significant part of the knowledge in our now's is anticipation of the future. Any futurist will admit that the goal of forecasting is not prediction but is figuring out what you need to know about the future in order to take effective action today (Saffo, 2007). From a high level perspective, we must ask, what is the sustainable knowledge that best ensures survival and the desired quality of life for our society? From an individual and community perspective, we must ask, what do I need to know next week, next month? What sustainable knowledge can I begin to build that will help me in tomorrow's now's?

As we are discovering from our unfolding understanding of how the brain works, sustainable knowledge is clearly the process of continuous learning through associative patterning—the semantic complexing of incoming information with that which is stored from our lived experience—taking the form of both Kn_I and Kn_P. In other words, for sustainability in our communities we must be able to find or have available robust sources of information through (1) facilitating the continuous flow of information needed for improvement and (2) developing the processes to assimilate, integrate and apply the knowledge we need. In a nutshell, this is the rich process of knowledge mobilization.

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