Considering Knowledge Uptake within a Cycle of Transforming Data, Information, and Knowledge

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Abstract

Knowledge uptake, having decision makers assimilate the ideas of experts, is recognized as an important stimulus to bringing about policy change. This is particularly true in the realm of environmental policymaking, which is characterized by knowledge intensity, complexity, and multifaceted concerns. Using examples from an innovative watershed management organization, this article presents a heuristic for understanding how knowledge uptake occurs within a cycle of organizational reasoning. This cycle is driven by activities that transform data, information, and knowledge and that link specialists with decision makers. The heuristic can be used as a diagnostic tool to identify breaks in the transformation process that impede mandate fulfillment and impair capacity building. Lack of appreciation of the dynamic relationship between data, information and knowledge leads to mistimed and ineffective policy interventions that do not result in the hoped for progress in science intended to underpin policy advances.

Introduction

To understand how events and actors shape the policy process, Kingdon (1984) and Dye (1995) each proposed a model of policymaking that draws on the idea of policy communities. A policy community consists of experts, activists, government program managers, and others, who exchange ideas, challenge each other’s positions, critique each other’s proposals and revise and enhance alternatives. Building on the tradition of Kingdon and Dye, scholarship developed about how policy change comes about through policy transfer or knowledge uptake. In policy transfer, governments learn from the experience of other governments. In knowledge uptake, decision makers locate, assess, and incorporate ideas from experts (Tepper, 2004). The traffic of ideas and influence is by no means one way. Experts work in organizations that to survive must astutely monitor and adapt to their political environments (Selznik, 1949).

The environmental policy domain is an instructive context in which to consider knowledge uptake within a cycle of transforming data, information, and knowledge that encompasses both experts and decision makers. It emerged relatively recently, developed rapidly into a mature field of government responsibility, and its policy changes have been far-reaching (Glasbergen, 1996). Environmental policymaking is knowledge intensive, complex, and concerns “scientific, technical, legal, policy and social issues” (Fiorino, 2001, p. 322). These attributes are equally characteristic of subsets of environmental policy, such as watershed management.

In environmental decision making, science and policy are linked through the cycle of transforming data, information, and knowledge. When it comes to decisions made by the few on behalf of the many, we like to believe that the process of reasoning is involved even while we recognize the limits of rational planning. We like to imagine that evidence or arguments derived from observations, facts, or hypotheses underpin, or at the very least, influence the basis of institutional action.
We implicitly value reasoning—cognitive processing that applies a rational procedure to solve problems (Colman, 2003). It is this valuation that reinforces the widespread acceptance that we live in a knowledge society (Drucker, 1989; Toffler, 1990) and that knowledge adds value in the workplace (Davenport & Prusak, 1998; Nonaka & Takeuchi, 1995); including the public sector (Simard, 2000). Consequently, increasing attention has been paid to how knowledge is created (Nonaka & Takeuchi, 1995) and reused (Markus, 2001).

The value placed on collective reasoning provides the rationale for pursuing management activities geared toward leveraging knowledge, information, and data created, retained, and disseminated within and beyond organizations. While this rationale has become accepted, less attention has been paid to the dynamic relationship between data, information, and knowledge. Lack of appreciation of this dynamic leads to mistimed and ineffective policy interventions that do not result in the hoped-for progress in science intended to support policy advances. An example of one such misadventure is presented later.

Participants in policy communities draw upon the organizational capacity of the groups in which they are based. Organizational capacity is predicated on group members contributing ideas (Innes & Booher, 2003a) that take different forms and contribute different pieces to the organizational puzzle. Considering an organization or a policy community as a scale of reasoning recognizes that developing knowledge is a social rather than an individual phenomenon (Fleck, 1979). While individuals are the wellspring of knowledge (Nonaka & Takeuchi, 1995) and the sole source of social learning (Heclo, 1974), on their own and through interacting with others they acquire and create “changed patterns of collective action” (Heclo, 1974, p. 306). It is through dissemination that what individuals know becomes a collective asset (DiBella & Nevis, 1998) on which organizational decision making can be based. Currently there is little to aid decision makers in diagnosing what has failed when the critical conversion does not happen. Consequently, this article presents a heuristic for understanding this transformation as a cycle of organizational reasoning that can be used to identify where transformation has failed to occur and to suggest what remedial action might be appropriate.

The next section presents our depiction of the relationship between data, information, and knowledge in the context of other authors’ explorations of the connections between these terms. After introducing the cycle of organizational reasoning, we briefly describe the Grand River Conservation Authority, the organization that we use as the source of examples of the four activities that propel the cycle: framing, systematizing, analyzing, and synthesizing. Each of these activities is discussed before two dimensions of organizational reasoning are highlighted: modes of reasoning and domains of engagement. Two applications of the cycle as a diagnostic tool are presented before the article concludes with how the heuristic of organizational reasoning as a cycle might be built upon.

The Relationships between Data, Information, and Knowledge

Organizational reasoning involves executing a set of interrelated rational activities to solve problems associated with fulfilling an organization’s mandate. These rational activities are rooted in transforming data, information, and knowledge.
Bukowitz and Williams (1999) define data as a set of discrete, objective facts, bits of raw material that have not been put in context. An example of datum is the river depth measured at a given location. It is a symbol inscribed by an instrument (Spiegler, 2003). A data set, for example, might consist of a set of river-depth measurements taken at different locations.

Information, according to Drucker (1989, p. 209), is “data endowed with relevance and purpose.” For example, the river-depth measurements are endowed with relevance and purpose when they are considered as indicators of low flow or flood conditions. Information exists in the eyes of the beholder because it is a judgment that the given data reveals distinctions (Spiegler, 2003). In this example the distinction is between conditions that do not require intervention and those that do.

In the context of problem solving, knowledge is derived from making information actionable (Vail, 1999). For example, knowledge is derived in deciding to act on the indicators of flow conditions. If the situation involves low flow, this may involve curtailing water withdrawals. In the case of flood conditions in a managed water system, this may involve holding back water in reservoirs. “Knowledge is the capacity for effective action in a domain of human actions” (Spiegler, 2003, p. 535). What is distinctive about knowledge is that it is created by the flow of information and is anchored in the knowledge holders’ beliefs and commitments (Nonaka, Konno, & Toyama, 2001). In the example provided, the knowledge holders are committed through their organization’s mandate to manage water supply.

Implicit in these definitions is that data is a building block for information, which in turn is a building block for knowledge. This leads to a situation where data is regarded as less than information and information is, in turn, less than knowledge (Tuomi, 2000). Consequently, the relationship between data, information, and knowledge traditionally has been understood to be hierarchic (Davenport & Prusak, 1998; Tuomi, 2000), as depicted in Figure 1. Such a hierarchy is evident in how the three terms were explained in relationship to each other in the previ-

![Figure 1. Conventional Hierarchy of Data, Information, and Knowledge](image_url)
ous paragraphs. In the traditional hierarchy, data can be a basis for generating information, so when the receiver adds value to data it becomes information. Likewise when the receiver adds insight, abstraction, and enhanced understanding, information becomes knowledge (Spiegler, 2003).

Tuomi (2000) has challenged this hierarchy and suggested reversing it (see Figure 2). He argues that knowledge is a prerequisite for information and information a prerequisite for data. His position is that all data is collected with specific purposes, assumptions, and expectations in mind and in a particular social and theoretical context. Underpinning this view is that the meaning of data is a function of the tools we create to measure what we are looking for (Tuomi, 2000), that human cognition requires that all data be part of a current structure of meaning (Spiegler, 2003). In Tuomi’s (2000) hierarchy, data is produced by putting information into a form that can be processed automatically. Indicators are the sets of rules for collecting and marshalling data so meaning can be assigned to them. Consequently, Innes (1990) has argued that before indicators are created we must know what policy we want.

Spiegler (2003) regards producing new knowledge as an unending, reflexive process that draws on both the traditional hierarchy of data, information, and knowledge and Tuomi’s (2000) reversed hierarchy of knowledge, information, and data. A cyclical depiction of the relationship between data, information, and knowledge is conceivable when data is understood as being both the basis and outcome of information and when information is understood as both the basis and outcome of knowledge (see Figure 3).

Spiegler (2003) depicts the relationship between data, information, and knowledge as a loop. It is hierarchic in that wisdom is the outcome of knowledge and reality is most directly accessed through data. He lists activities associated with moving from reality to data, data to information, from information to knowledge and from knowledge to wisdom. Not listed in the loop are the actions associated
Consider the portion of the loop from knowledge to information, information to data and data to reality.

**The Cycle of Organizational Reasoning**

In developing the cycle of organizational reasoning (see Figure 4) we recognized two critical dimensions. The first is that information is the intermediary between data and knowledge whether one is generating data from knowledge or creating knowledge from data. Yet, the activities associated with processing information in the top half of the cycle are different from those in the bottom half. In the top half, knowledge is transformed into data through a process of codification. Conceptual categories are used to classify phenomena and the links between phenomena. In
Building on an appreciation of cause and effect relationships, people discern the underlying structure of phenomena pertinent to their objectives (Kawalek, 2004).

A second dimension to recognize about the cycle of organizational reasoning is that the different activities individuals within an organization undertake that relate to data, information, and knowledge drive the counterclockwise rotation. Before presenting these activities, we introduce the organization that is the source of the examples that will be used to illustrate these activities.

**The Grand River Conservation Authority (GRCA)**

The Grand River Conservation Authority (GRCA) is one of the 36 conservation authorities that operate in watersheds in which 90% of the population of Canada’s most populous province reside (Conservation Ontario, 2000). The conservation authorities of Ontario, Canada, operate in the environmental policy domain as community-based, quasi-government agencies mandated by provincial legislation, the 1946 Conservation Authorities Act, to conserve, restore, develop, and manage natural resources through an integrated approach, on a watershed basis. They plan, coordinate, and manage on behalf of municipalities within a watershed. As such they are active players in what Kooiman (1993, p. 2) describes as “social-political governance.” Consequently, to fulfill their mandates, conservation authorities must interact on an ongoing basis with social actors, groups, institutions, and authorities. The policy realm of conservation authorities is one in which no one entity has either all of the requisite knowledge and information to solve complex, evolving, multifaceted problems, a sufficient overview to apply the necessary instruments effectively or can completely dominate on its own the system of governance (Kooiman, 1993).

As part of its watershed management responsibilities, the GRCA collects and analyzes data and assembles information. It creates knowledge on its own or with its partners to enable those who live and work within the watershed as well as different levels of government “to make informed decisions about the watershed and its resources” (Grand River Conservation Authority, 2003, p. 1). For example, the GRCA generates the data on surface water flows by measuring it at different places and assembles the data to create the information about the pattern of water levels throughout the Grand River and its tributaries. When drought conditions exist or are anticipated, this information is reviewed by the Grand River Low Water Response Team. Representatives from the GRCA, various levels of government as well as agricultural, aggregate, and golf course operations discuss watershed conditions and actions that different water use sectors can take to reduce stress on the natural environment. Team participation makes it easier than it would be otherwise for water users, such as aggregate operators, to accept reducing water extraction in their operations.

Participating in developing knowledge is fundamental to buying in to make decisions based on knowledge and on implementing the outcome of those decisions (Innes, 1998). Collaborative policymaking enables participants to learn and act productively by linking agents who can make things happen and establishing conduits
for information and feedback (Connick & Innes, 2003). It is the interdependence of participants that allows them to create a robust and effective adaptive learning system through the results of their interaction. Their motivation to work together to respond to change is a function of their recognition that they share a common problem and so cannot on their own meet their own interests (Innes & Booher, 2003b).

**Activities That Drive the Cycle of Organizational Reasoning**

Different members of an organization undertake different activities that propel the cycle (see Figure 5). We illustrate this using selected activities carried out by four members of the Grand River Conservation Authority.

*Frame: From Knowledge to Information*—Organizational members who are engaged in transforming knowledge into information frame the purpose and expectations for codifying information. This occurs as they develop knowledge-based implementation strategies for the issues for which decision makers allocate resources. In this way, organizations adapt to their political environments (Selznik, 1949). The development of strategies and the review of knowledge on which they are based may be done by a policy community as an interorganizational enterprise with the understanding that implementation will occur primarily within individual organizations. The expectation of where implementation will take place may be a consideration in who is represented in the collective development of the strategies. For example, the chairman of the GRCA, who is also chair of Conservation Ontario, the association of Ontario conservation authorities, serves on a 21-member provincial expert source water protection committee along with those from municipalities, First Nations, agriculture and other industries, and environment and health groups. This implementation committee advises the provincial government on the tools and strategies conservation authorities, municipalities, and the province might use in executing their respective responsibilities for implementing watershed-based source protection planning.

*Systematize: From Information to Data*—The primary activity in creating data from information is to systematize what is understood to enable analysis. This may involve recategorizing information, developing organization-wide protocols for
data management, providing centralized data maintenance systems, or devising a process where the maintenance can be decentralized. The manager of information systems of the GRCA designs information technology tools and designs the structure of datasets to address the conservation authority’s information management needs.

**Analyze: From Data to Information**—Organizational members who analyze data draw out useful patterns or attribute some measure of meaning to the data. They lay the groundwork for abstracting information by producing results through analysis and interpretation of data (Bourdreau & Couillard, 1999). For example, the Water Information Specialist at the GRCA standardizes data, ensures the accuracy of data collected, and analyzes it to generate information.

**Synthesize: From Information to Knowledge**—The challenge in transforming information into knowledge is to move from information sharing to making information actionable. For example, this may involve deciding to upgrade a sewage treatment facility based on reviewing water quality information. Information generated within the organization is made available to a network of policy influencers for direct and indirect use in decision making. For example, the Senior Water Quality Supervisor at the GRCA facilitates the Water Managers Working Group. Made up of representatives from municipal, provincial, and federal governments, First Nations, and conservation authorities, the working group is engaged in implementing work plans for Grand River watershed management. In a sense, the working group functions as a facilitated policy community in which actors have strong personal contacts and are familiar with each other’s ideas and proposals (Kingdon, 1984).

**Modes of Reasoning and Domains of Engagement**

For heuristic purposes, the cycle of organizational reasoning can be bisected in two ways. The first is by mode of reasoning. The second is by domain of engagement. In both of these bissections one half can be distinguished from the other even while the joins between them are potentially seamless.

**Deductive and Inductive Reasoning**—Creating organizational reasoning employs both deductive and inductive reasoning (see Figure 6). In the top half, deductive reasoning is employed to develop empirical from conceptual knowledge. Inductive reasoning dominates the bottom half, in which knowledge is derived from creating patterns of information derived from empirical observation and computer simulation.

**Expertise-Organized and Context-Brokered Domains of Engagement**—The right side and the left side of the cycle can be delineated by who and how is mediating the information (see Figure 7). The left hand side is the domain of specialists working with other specialists to maximize the substantive base of the issue. The right hand side is the domain of engagement between members of the organization and those outside who draw on a range of proficiencies. The brokering that occurs on this
side does so because even the most powerful entities cannot on their own unilaterally get the outcomes they seek (Innes & Booher, 2003b).

**Diagnostic Potential of the Cycle of Organizational Reasoning**

We propose that a prime use of the organizational reasoning cycle is as a diagnostic tool for assessing the robustness of organizations. Understanding the cycle and its drivers enables those within organizations to begin to identify what works and what does not work in their effort to create and facilitate organizational reasoning. Two applications of the cycle of organizational reasoning as a diagnostic tool are presented here.

**Identifying Breaks in the Linkages between Activities**

The cycle makes plain how members of an organization who perform different activities contribute to creating organizational reasoning. The linkages and dependencies between different organizational members whose activities together drive the cycle are discernable, as are the gaps. It is equally possible to use the cycle to map where organizations are missing driving activities and the links between them. To create organizational reasoning, it is not enough to be highly skilled in one
driving activity or even in all activities if they each operate as silos. The importance of sharing data, information, and knowledge necessitates that for an organization to operate effectively it must collaborate internally and externally (Innes & Booher, 2003a).

When to Fund What Type of Activities

An appreciation of the different activities that drive the cycle and the connections between them is essential. Equally important is locating the state of a policy issue in the cycle of organizational reasoning. Failure to do so correctly can lead to the misallocation of resources. For example, in an era when the Province of Ontario was anxious to demonstrate its commitment to source water protection, it invested heavily in technical studies before well-justified scientific frameworks were in place. The province was investing heavily in systematization before framing was sufficiently far along to guide systematization activities. Recognizing that policy activity was still centered on framing may have caused provincial officials to reconsider how and when they could most effectively intervene. One possibility is that funds for systematization activity could have been tied to outcomes from framing.

What Next for Deciphering Organizational Reasoning?

We have brought to the fore one subsystem, organizational reasoning, and implicitly put a boundary around it. The boundary is permeable and links to more familiar action-based systems, such as those for planning, implementation, communication, and learning. Subsequent work on organizational learning to facilitate policy change could profitably probe these linkages.

While we have described one iteration of the organizational reasoning cycle, the data, information, and knowledge generated for decision making and the decisions that result, in turn, provide the basis for the next iteration of the cycle. Each iteration lays down a layer on which subsequent ones build. For example, decisions made in the act of synthesis (see Figure 5) may be based on combining information developed within the most recent cycle and information generated in previous cycles.

When members of an organization or a policy community strive to refine and improve what they are doing, their learning activities drive the iterative spiral of organizational reasoning. Learning, beginning with searching for what to do (Rose, 1993), is a response to dissatisfaction. It involves correcting errors, mismatches between what we intend an action to produce and what happens when that action is implemented (Argyris, 1993). The discrepancy between intent and outcome can be a function of the response lag to a ceaselessly shifting context. Organizational reasoning spirals, in part, because the mismatch between what is being done and what needs to be done is untenable. It also spirals because organizational reasoning incorporates reflexivity, the constant examination and reform of social practices in light of information about those practices, “thus constitutively altering their character” (Giddens, 1990, p. 38). The potential exists for the spiral to collapse. It may do so from such causes as a break in institutional memory or a regime change. Future work may consider more fully the dynamics of the spiral of organizational reasoning.
The Grand River Conservation Authority is an organization that engages in all of the activities associated with the cycle of organizational reasoning either in-house or in collaboration with partners. Further testing of the utility of the heuristic will require considering its explanatory utility for organizations, such as consulting firms, that specialize in activities associated with three or fewer of the activities that drive the cycle. Also, it would be worthwhile to consider the applicability of the heuristic to governance networks.

**Summary Remarks**

This article has introduced the concept of organizational reasoning as a means to shed light on the linkage between specialists and decision makers and the relationship between data, information, and knowledge. Appreciating the nature of the linkages between specialists and decision makers furthers our comprehension of how knowledge uptake occurs and how the engagement of decision makers shapes what expertise specialists develop and communicate. Understanding the relationship between data, information, and knowledge as a cycle enables us to identify how distinctive activities undertaken by different members of an organization come together in the collective pursuit of reasoning as a means to fulfill an organization’s mandate. This pursuit builds organizational capacity. Ideally, this results in knowledge uptake within an organization and within the policy communities in which organizational members participate. The process of knowledge uptake can fuel policy change. The heuristic of organizational reasoning as a cycle is constructive as a diagnostic tool. It is helpful in identifying breakdowns in the linkages between activities that drive the cycle and in determining when and where policy intervention may be most useful. The initial application of the heuristic is sufficiently promising to suggest further work is warranted. The true measure of any heuristic is its value in encouraging thinking that extends the range of possibilities in practice and theory.

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