DATA, INFORMATION, KNOWLEDGE, AND WISDOM

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Summary

The peoples of the earth are faced with environmental damage inflicted by unsustainable patterns of growth and development that could threaten our ability to sustain human populations. Gathering information concerning the state of the planet, gaining knowledge concerning what the information means for sustainable development, and acting wisely in developing policies to manage activities globally is imperative. A necessary step in this process is to be clear about the nature of data, information, knowledge, and wisdom. This article introduces and explores each of these concepts, pointing out their complexities, their relationships to one another, their uncertainties, and their optimal use. Data are defined as simple facts, either quantitative or qualitative. Information is defined as organized data. Knowledge is defined as the ability to understand the meaning of information. This meaning is highly specialized; it changes as the context changes, as information is derived by different methods and mechanisms or communicated by different persons, and as the use to which it will be put changes. Wisdom is defined as the ability to act appropriately on knowledge. It requires an interdisciplinary synthesis and is informed and driven by values. As such it requires a sense of community and an atmosphere of trust to flourish. The gist of this article is that data, information and knowledge are necessary but not sufficient for supporting sustainable development and global security. Moving beyond knowledge concerning what information means to actions driven by a collective wisdom is essential.

1. Introduction

According to business and labor leaders, the developed free-market countries are in the midst of a transformation to a knowledge society, a society in which knowledge will be the primary personal and economic resource. Developing countries will be close behind, transforming in similar ways. Natural resources, labor, and capital, long considered to be the only meaningful resources, will become secondary; they can be obtained and managed only if there is knowledge. In the new economy, what is truly valuable is the ability to *use* knowledge effectively, creatively and wisely. At the same time, the peoples of the earth are faced with environmental damage inflicted by unsustainable patterns of growth and development that could threaten our ability to sustain human populations.

Within this context, gathering information concerning the state of the planet, gaining knowledge concerning what the information means for sustainable development, and acting wisely in developing policies to manage activities globally is imperative. A necessary step in this process is to be clear about the nature of data, information, knowledge, and wisdom. This article introduces and explores each of these concepts, pointing out their complexities, their relationships to one another, their uncertainties,

and their optimal use. Data will be defined as simple facts, either quantitative or qualitative. Thus "16,562,000" is a quantitative datum, while "The population of Mexico City is large" is a qualitative datum. Information will be defined as organized data. Thus, Table 1 provides information.

Source: United Nations, Dept. for Economic and Social Information and Policy Analysis						
		A	**B**	**C**	**D**	**E**
Rank	**City, Country**	**Pop**	**Pop**	**Annual**	**Percent Increase**	**Percent Increase**
		(thousands)	**(thousands**	**Growth Rate**	**for:**	**for:**
			projected)	**(percent)**	**1975-**	**1995-**
		1995	**2015**	**1990-1995**	**1995**	**2015**
1	Tokyo, Japan	26,959	28,887	1.45	36.36	7.15
2	Mexico City, Mexico	16,562	19,180	1.81	47.4	15.81
3	Sao Paulo, Brazil	16,533	20,320	1.84	64.56	22.91
4	New York City, U.S.	16,332	17,602	0.34	2.85	7.78

Table 1: Population of the World's Largest Cities

Knowledge will be defined as the ability to understand the meaning of information. This meaning is highly specialized; it changes as the context changes, as information is derived by different methods and mechanisms or communicated by different persons, and as the use to which it will be put changes. Wisdom will be defined as the ability to act appropriately on knowledge. It requires an interdisciplinary synthesis and is informed and driven by values. As such it requires a sense of community and an atmosphere of trust to flourish.

Data and information have been carefully analyzed for quite some time, and much has been learned. Knowledge and wisdom are more elusive, and even though they have been the subject of philosophical discourse for centuries, these concepts have just recently been revisited in an effort to derive practical guidance from them. The increasing inclusion of diverse voices (specifically, women and "non-western" voices) has led to significant advances in our understanding of the nature of knowledge. A whole set of subjective factors – gender, race, class, age, education, historical location, religious and political identifications, and personal careabouts and enthusiasms – has been determined to be significant to knowing and knowledge. Furthermore, knowers are now recognized to be epistemically dependent upon one another; this dependence makes creating, holding, applying, and sharing knowledge a collaborative effort. Research also suggests that there are multiple ways of knowing that can make efforts at collaboration both more difficult and, ultimately, more productive. Finally, knowledge and values are intimately connected. We come to know what we care to know, and thus a full accounting of our knowledge will include the values that drive it.

Knowledge alone is not enough, however. To thrive on a planet with increasing populations and diminishing resources, appropriate action must be taken on existing knowledge. This requires negotiating meanings and values across disciplines and across cultural differences. It requires a knowledge community that allows for trusting epistemic relations, not just interactions. Aristotle's notions of intellectual and moral virtue are helpful in understanding how the development of intellectual and moral character can create the motivation required to apply knowledge wisely.

The gist of this article is that data, information and knowledge are necessary but not sufficient for supporting sustainable development and global security. Moving beyond knowledge concerning what information means to actions driven by a collective wisdom is essential. The nature of data and information is relatively well understood; obtaining data and presenting information pose challenges that will be discussed below. Knowledge and wisdom are less well understood. Thus this article will begin with brief discussions of data and information, and focus most attention on knowledge and wisdom.

2. Data

Masses of data by themselves have little or no value. Nonetheless, the careful collection and storage of relevant data is essential to any knowledgeable enterprise. Data collection at an international level presents multiple difficulties such as:
• disagreement concerning which data are relevant
• lack of consistent definitions
• use of different statistical methods
• gaps in data as a result of haphazard collection efforts
• inaccurate data as a result of flawed collection methods
• the overburdening of data collection systems

When data are intelligently organized they convey information, and what information is conveyed depends upon just how the data are organized.

3. Information

Information is organized data. Database technology, statistical analysis software, and graphing software allow the electronic storage, transmission and display of data in myriad forms and configurations. Indeed, the dissemination of information has been made so easy that problems of information overload have been created. Careful decisions must be made concerning what information should be given, to whom, and how often. Answers to these questions are highly context dependent, and require the combined expertise of domain specialists, computer technologists, and policy makers.

One question regarding information that deserves close attention is this: How should the information be presented? When the right data are in the right place at the right time and are organized in the right way they become information. Research has shown that some methods of displaying and analyzing data are better than others, and this means that the movement from mere data to information must be undertaken with care. Policy makers base their policies on the information available to them, and the organization and

display of data that constitute that information can have momentous consequences. Two cases will serve to illustrate this important point.

3.1. The Decision to Launch the Space Shuttle Challenger

On January 28, 1986 the U.S. space shuttle Challenger exploded and seven astronauts died. The cause of the accident was traced to two rubber O-rings that lost their resiliency because of the cold temperature (ambient temperatures were in the low 30s and the O-rings were less than 20^0 F) on the day of the launch. Lacking resiliency, the O-rings leaked, and a torch-like flame burned through the side of one of the booster rockets. That flame engulfed the fuel tank, which then ruptured and exploded, destroying the shuttle. In his book *Visual Information*, Edward R. Tufte gives a fascinating analysis of the information available to those who made the decision to launch the shuttle. This information consisted of 13 charts prepared by the Morton Thiokol engineers who designed the rocket. The information was faxed to NASA, the government agency responsible for the flight, on the day before the launch. Based on this information, the Thiokol engineers opposed the launching, their first "no launch" recommendation in 12 years. The charts failed to convince the decision makers and NASA, however, and the launch was approved.

All of the data to support a no-launch decision were available at the time of the launch decision. The problem was that the charts failed to display the relevant data in a way that the causal relationship between cold temperatures and O-ring failure could be seen. For example, one chart displayed data about blow by (soot detected in the joints upon post-launch examination) and temperature for two launches. No data about erosion of the O-rings were included, and the data were limited to just two launches. Other charts provided data for test motors, data showing no O-ring erosion on warm day launches, and data showing some erosion on warm day launches. What was needed was a table that showed the complete history of temperatures and O-ring conditions for all 24 previous launches. Had the data been displayed in such a table, it would have been obvious that the Challenger would be at risk. While two launches on warm days resulted in some O-ring damage, every launch below 66^0 F resulted in damaged O-rings. The Challenger was scheduled to be launched at temperatures predicted to be 29^0 F, a full 37^0 F cooler than 66^0 F.

What can be learned from this story? Some ways of organizing data are better than others. Data are organized and information is displayed to support particular intellectual tasks. The way in which this is done significantly affects the ability of decision makers to make knowledgeable decisions.

3.2. The Framing of Medical Decisions

Research has shown that the way in which data are framed and problems formulated can have a significant impact on how people make decisions. McNeil, Pauker, & Tversky report on a series of studies that show that preferences among options for medical treatment are influenced dramatically by the way in which data concerning probabilistic outcomes are organized and presented. In one study participants were given a choice

between two treatments for cancer: surgery or radiation therapy. Statistical data regarding the effectiveness of the two therapies at three different points in time were given: immediately after treatment, after one year, and after five years. The data indicated that surgery presents a greater immediate risk than radiation therapy, but offers a higher life expectancy. All participants received the same information, but the data were framed differently. For one half of the participants data were framed in terms of mortality, or the percentage of patients who died; for the other half data were framed in terms of survival, or the percentage of patients who survived. When survival rates for radiation therapy were given and compared to survival rates for surgery (100% for radiation therapy, 90% for surgery), 18% of respondents favored radiation therapy. When the same data were framed in terms of mortality (10 %for surgery, 0% for radiation therapy), 44% of respondents favored radiation therapy. This dramatic effect on choice was the same across populations of clinic patients, statistically astute business students and experienced physicians. Furthermore, the effect did not change significantly when the therapies were identified simply as "Therapy A" and "Therapy B."

Other studies documented similar effects for participants given options for lung cancer therapies and for couples deciding whether to forego pregnancy in the face of a specified risk of an abnormal child. When mixed frames (mortality and survival) were presented the results were intermediate between the results for mortality and survival. In all of these studies, the same data were presented to all participants. Their responses varied depending on how the data were organized or framed.

There appears to be no "right" way to frame data. The fact that different formulations produced reliably different results suggests that a single frame is not entirely adequate. Because mixed frames draw attention to both positive and negative aspects, it might be argued that mixed frames are to be preferred. At the very least, these studies suggest that serious consideration must always be given to the framing of information.

3.3. So what?

Data have been gathered and organized into information for centuries. Computers have made the process more efficient, but haven't alleviated the problems posed by inconsistent definition, haphazard collection, and data gaps. Because data are the foundation upon which information, knowledge and wisdom rest, it is essential that data gatherers be alert to these problems. A thoughtful information display of inconsistently defined data elements serves no one well. Additionally, data must be organized in a manner that best addresses the questions being asked and the problems being addressed. Awareness of the power of information to mislead, misinform, and to bias decisions is a significant step toward the proper management of information. The examples discussed here have easy analogies to the domain of sustainable development. Simply change the question from:
    "Will the low predicted temperature have an adverse effect on the O-rings?"
to "Will the predicted rise in temperature have an adverse effect on crop production?"
or "Will the rise in population have an adverse effect on air quality?"

Answering such questions and acting wisely on behalf of the planet are unrealistic goals

unless data are gathered carefully and information is presented thoughtfully. Even in the best of circumstances, however, information isn't enough. Knowing what to do entails grasping the meaning of information. Acting wisely requires motivation driven by appropriate values.

4. Knowledge

Assume perfect data appropriately presented as information. What is involved in knowing? What is involved in grasping the meaning of information? What, precisely, is knowledge? And where is it? And what are its important features? Recent research into the nature of human knowledge and human knowers has uncovered six features that characterize knowledge, knowers, and the act of knowing:
1. Knowledge is situated
2. Knowers are epistemically dependent
3. Knowledge requires trust
4. Knowledge and values are intimately connected
5. Knowledge can be tacit as well as explicit
6. There are multiple ways of knowing

The discussion that follows is made difficult by the fact that knowledge is multifaceted. Knowledge can be thought of as a product, such as an interpretation of the meaning of Table 1. It can also be thought of as a process of coming to know, such as coming to know the meaning of the information presented in Table 1. Both the product and process are intimately connected to the knowers who generate them. Readers are advised that the focus in the discussion that follows will shift from product to process to knowers and back again as required by the context.

4.1. Knowledge is Situated

It is tempting, and perhaps traditional, to think of knowledge as something that develops and resides in people's heads. Indeed, the image of Rodin's thinker is well-known, at least to many Westerners, and epitomizes this view of knowledge and knowers – knowledge is a pure, abstract and permanent commodity, and knowers are solitary, independent beings. This presumption has strongly influenced the way in which many knowledge management efforts have proceeded, and may account for some of their difficulties. While there certainly are some situations in which knowledge is permanent and in which we come to know primarily in an independent fashion, the presumption that the pursuit of knowledge is ideally an individual pursuit divorced from historical, social, or even biological context, and that knowledge is "in the head" of the knower is misleading and in most cases false.

Consider again the information presented in Table 1. The information is provided by the United Nations Department for Economic and Social Information and Policy Analysis. This organization has gathered the data that populates Table 1 and has organized it according to the schema shown. What can be known on the basis of the information provided on Table 1? Answering this question requires consideration of the context in which knowledge is generated and understood. Knowledge, indeed, is situated and can be understood only relative to its particular context, which is at once political, corporate,

physical, social, and psychological.

4.1.1. What is context?

The word "context" comes from the Latin, *contexere,* which means "to weave together, to join together, to compose." To say that knowledge is situated in a context is to say that what knowledge is is a function of the weaving together of the elements that make up context. It is the interconnected whole that gives meaning to the parts. But what are the parts? What are the elements that constitute context? At the very least, the following elements constitute the context in which knowledge gleaned from Table 1 is situated:

- the global environment
- the culture of the United Nations Department for Economic and Social Information and Policy Analysis
- the physical setting, or "the room" in which the Table is generated
- informal knowledge communities
- personal knowledge sources
- the knowers themselves

All these elements, woven together, constitute context. The elements are dynamic and ever-changing, are interpreted by individual knowers, and are woven by them into the fabric of their knowledge. Understanding knowledge requires understanding of both what each of these elements is, and also how individual knowers interpret them. Notice the complexity of knowledge relative to simple data. A number may just be a number, but the manner of its presentation as information and the meaning that can be culled from it are complex indeed!

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Bibliography

Aristotle (1941). Nichomachean Ethics. *The Basic Works of Aristotle* Ed. R. McKeon. New York, Random House. [This classic work provides an account of intellectual and moral virtue].

Code, L. (1991). *What Can She Know?* Ithaca, Cornell University Press. [This work explains the role of subjectivity in knowledge].

Gardner, H. (1989). *Frames of Mind*. Basic Books. [This work introduces and explains the notion of types of intelligence].

Goleman, D. (1995). *Emotional Intelligence.* New York, Bantam. [This work explores the nature of emotional intelligence].

Hardwig, J. (1985). "Epistemic Dependence." *Journal of Philosophy* 82: 335-349. [This work clearly explains why and how humans are dependent on one another in knowing].

Polanyi, M. (1966). *The Tacit Dimension*. Garden City, Doubleday. [This classic work explains the notion of tacit knowledge].

Sternberg, R. J. (1990). *Wisdom: Its Nature, Origins, and Development*. Cambridge, Cambridge University Press. [This edited volume presents recent research on the nature of wisdom].

Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge, Cambridge University Press. [Using a detailed, concrete example, this work explores the nature and importance of communities of practice].

Wiig, K. M. (1993). *Knowledge Management Foundations.* Arlington, Schema Press. [This work provides an analysis of knowledge in a business context].

Zagzebski, L. T. (1996). *Virtues of the Mind.* Cambridge, Cambridge University Press. [This work explores the notion of intellectual virtue].

Biographical Sketch

Sue P. Stafford is Associate Professor and Chair of the Philosophy Department at Simmons College, Boston, Massachusetts, U.S.A. She specializes in epistemology, ethics and technology, and philosophy of mind. In addition to over 20 years of teaching experience, Dr. Stafford has worked as a consultant for over 15 years in the areas of artificial intelligence, knowledge engineering, and knowledge management, first at Arthur D. Little in Cambridge, Massachusetts and then at Coopers & Lybrand in Boston; she currently consults independently. Her clients have included major financial and manufacturing institutions as well as government agencies such as NASA and the Environmental Protection Agency. Projects have included knowledge engineering work for a weather forecasting expert system for NASA, a pollution forecasting expert system for Mexico City, and a watershed management system for Massachusetts, as well as numerous seminars on knowledge elicitation, analysis, and modeling. Dr. Stafford publishes widely in the areas of epistemology, ethics and technology. Recent articles include: "Capitalizing on Careabouts to Facilitate Creativity", which appeared in the journal *Creativity and Innovation Management* (1998). Dr. Stafford holds a B.A. in philosophy from Wheaton College, an M.A. in philosophy from the University of Illinois, Chicago Circle, and a Ph.D. in Philosophy from the University of Connecticut.