

THE ARCHITECTURE OF KNOWLEDGE

It is all too easy to confuse data with knowledge and information technology with information.

Peter Drucker

Knowledge of the spirit world is to be obtained by divination; information in natural science may be sought by inductive reasoning; the law of universe can be verified by mathematical calculation

Sun Tzu, Chinese writer of 6th century BCE

‘Dynamic Model of Production and the Evolution of the Knowledge Economy’, another report of this series, analyzed the production models which treat ‘knowledge’ as an element of production. The present report reviews the nature and content of knowledge. Contemplating a comprehensive architecture for knowledge is a compelling task. We are facing a tough challenge: **How do we perceive knowledge?**

There exist sundry references to knowledge’s role in a wide range of disciplines varying from sociology to economy, and from engineering to management. Our knowledge of the concept of knowledge, however, is still far less than required. Nico Stehr argues that “among the most serious general theoretical deficiency of existing theories of modern society, that assign a central role to knowledge, is their rather undifferentiated treatment of the key ingredient, namely knowledge itself. The crucial importance assigned to knowledge within these theories has not been matched by extended and enlightened discussions of the concept of knowledge. Our knowledge about knowledge is, in many ways, not very sophisticated¹”.

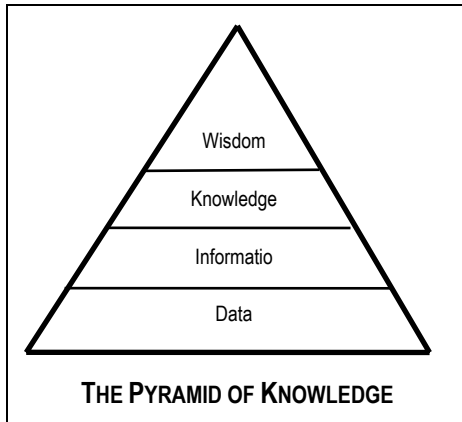
The development of accurate definitions or descriptions for knowledge, as well as how knowledge relates to other aspects of intelligence and consciousness has never been easy. We should remind ourselves that there may be as many definitions of knowledge as there are people who regard themselves as knowledgeable².

Alvin Toffler uses knowledge as a generic term, which includes data, information, images, symbols, culture, ideology, and values³. Toffler asserts that any data, information, or knowledge that is communicated requires a source or sender, a set of channels or media through which the message flows, a receiver, and a message⁴. Information may come in a wide range of forms, including verbal, documented instruction manuals, blue prints, computer software, etc.

Daniel Bell (1973⁵) defines knowledge 'as a set of organized statements of facts or ideas, presenting

a reasoned judgment or an experimental result, which is transmitted to others through some communication medium in some systematic form.' In this context, he distinguishes knowledge from news and from entertainment. Knowledge consists of new judgment (research and scholarship) or new presentation of older judgments (textbook and teaching).

Although there is no official and generally accepted definition for 'knowledge', there exist many references to a hierarchical organization among 'data', 'information', 'knowledge' and 'wisdom'. A formation for this classification, called the 'Pyramid of Knowledge'⁶, is depicted here.

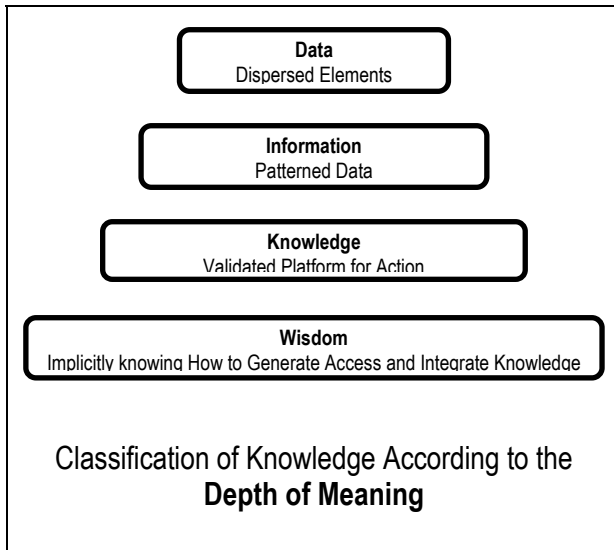


Al Gore suggests that information is first distilled into knowledge, which is then - sometimes - fermented into wisdom⁷. Russell Ackoff's view towards knowledge, may have been inspired by the same organization:

A pound of 'data' is worth an ounce of 'information'
A pound of 'information' is worth an ounce of 'knowledge'
A pound of 'knowledge' is worth an ounce of 'understanding'
A pound of 'understanding' is worth an ounce of 'wisdom'

T. S. Elliot seems, however, has another interesting point of view on the same topic:

Where is the knowledge, which is lost in information?
Where is the wisdom, that is lost in knowledge?



Another configuration about the relationship among "data", "information", "knowledge" and "wisdom" is depicted in the next figure⁸. This model, organized according to the depth of meaning, regards data as dispersed elements, information as patterned data, knowledge as a validated platform for action, and wisdom as implicitly knowing how to generate, access and integrate knowledge.

King and Schneider (1991) provides another point of view towards knowledge and information. They argue that science's process explores the unknown and provides new data. Data is not in itself information but the raw material of information. Through selection with a

sense of relevance, human intelligence orders and coalesces data to produce information. A matrix of information can become knowledge. Again, knowledge does not spontaneously generate understanding; this requires wisdom born of experience. Thus we are concerned with a continuum which runs from crude data, through information and knowledge to the end refinement of wisdom.

Data we possess in large quantities and information can easily be concealed or lost in disorder. Today we have enormously greater amounts of information and knowledge about man and the universe than our forefathers had, but there are few signs that human wisdom has increased significantly over the last 5,000 years. In these difficult and complex times we begin to realize that the pursuit of wisdom is the essential challenge that faces humanity⁹.

Back in the 1920s, Max Scheler's sociology of knowledge distinguishes the following categories: (1) knowledge of salvation, (2) cultural knowledge, or knowledge of pure essence and (3) knowledge that produces effects. Nico Stehr simply defines knowledge as a capacity for action¹⁰.

Michael Polanyi (1966¹¹) made the distinction between 'explicit' knowledge, which can be articulated in formal language and transmitted among individuals, and 'tacit' knowledge, personal knowledge embedded in individual experience and involving such intangible factors as personal belief, perspective, and values.

Ruddy Ruggles (1997¹²) provides another approach towards the definition of knowledge as “a fluid mix of contextual information, values, experiences, and rules. It comes in many forms including process knowledge (how-to), catalog knowledge, (what is), and experiential knowledge (what was).

In addition to the above descriptions of knowledge, there exist of course other, sometimes contradictory, opinions of what constitute knowledge: ‘knowledge: the articulation of human experience and adaptive knowledge acquires evolutionary significance¹³’ and ‘information: the alienation of human experience¹⁴’.

Engineering-oriented studies have another approach towards information and its relationships with data and knowledge. Information is considered to be some tangible or intangible entity that reduces uncertainty about a state or event. In this sense, information has been related to certainty, which by itself is related to access to information. This approach is consistent with Claude Shannon’s work on so-called ‘information theory’. Claude Shannon was the mathematician who in the 1930s recognized how to express information in binary form. During World War II, he began developing a mathematical description of information and founded a field that later became known as ‘information theory’. Shannon defined information as the reduction of uncertainty¹⁵.

‘Artificial intelligence’ regards data as the ‘raw’ material of information. Information is the ‘what’ of what is represented. Knowledge is the ‘what’ and ‘how’ of what is represented. An information system is a set of organized procedures that, when extended, provides information for decision making, communications, and/or control of the organization. Information system components consist of ‘acquisition’, ‘communication’, ‘storage/retrieval’ and ‘presentation’¹⁶. In addition, data has also been considered as facts in isolation. Information is data refined relative to a specific decision-making context. One person's information is another person's data¹⁷. ‘Information technology’ concentrates on the technical aspects of processing, communicating and transferring information.

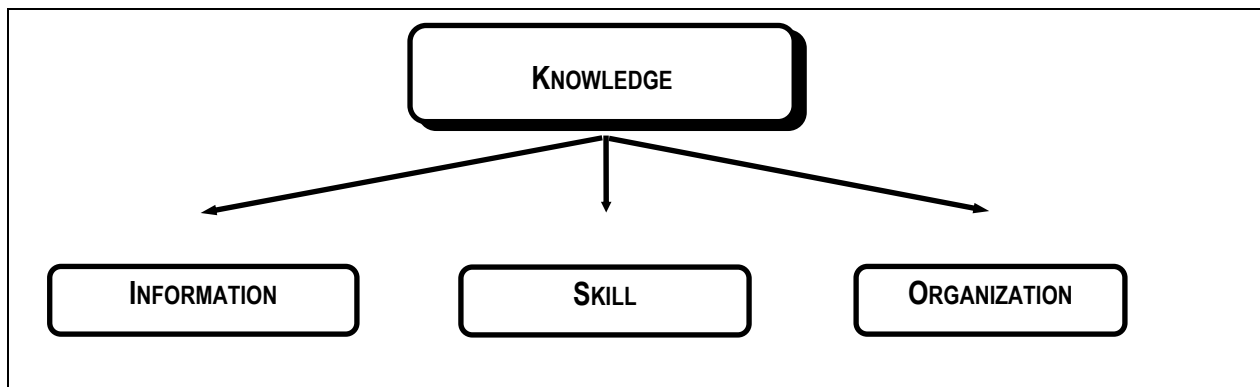
Stan Davis and Jim Botkin¹⁸ provide the following insight towards data, information and knowledge: *Information* is the data that have been arranged into meaningful patterns. Numbers are data; a random number table is information. Knowledge is the application and productive use of

information. Sounds (converted into notes) are data that can be arranged in an infinite number of systems to produce the information we call music. Whenever a piece of music becomes the stuff of *knowledge* -whether, that is, it enables those who hear it to learn - depends not only on the composition but also on the skill and purpose of the performer.

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The above sources all discuss some aspects of information and knowledge; however, obviously they are neither mutually exclusive nor sufficiently comprehensive. In addition, the above sources make no reference to other important aspects of knowledge, for instance 'skill', 'idea', 'organization', and 'innovation'. It appears humans are far from being able or in a position to express themselves clearly about 'knowledge' and its content and context.

To facilitate the development of the architecture of knowledge, pragmatically 'knowledge' may be classified under three main topics: 'Information', 'Skill' and 'Organization', as depicted in the following diagrams:



Information, in the above context, includes codifiable and documentable knowledge. Information, as the documentable knowledge, can have a wide range of carriers, varying from clay to stone and from paper to electronic devices. Documented knowledge may be further codified into data, usually in a binary form. The information theory, discussed before, deals practically with data processing and transmission. Bruce Kogut and Udo Zander (1992¹⁹) regard information as the knowledge which can be transmitted without loss of integrity once the syntactical rules required for deciphering it are known. Information includes facts, axiomatic propositions, and symbols.

Skill incorporates the mental and manual aspects of human capabilities. One must distinguish between the content of knowledge and the skill capability. Drucker (1994²⁰) emphasizes that skills, in contrast to information, change slowly and infrequently. Eric von Hippel (1988²¹) considers know-how as "the accumulated practical skill for expertise that allows one to do something smoothly and efficiently". The pivotal word in this definition is "accumulate," which implies that know-how must be learned and acquired.

Organization covers all other aspects of knowledge that cannot be classified under information or skills. Organization in this context may embrace structure, methodology, culture, attitude, values,

even social myths. 'Organization is one of the greatest facts of contemporary life. It accounts for the most significant achievements of human life and goes far beyond both the physical and intellectual reach of the individual. It does this by combining diversely specialized intellectual qualifications for results superior to those otherwise available. And since many varied scientific, engineering and experiential qualifications bear upon each decision, the organization encompasses the crucial power of decision. The future theory of production, if it is to have relevance, will probably be a theory primarily of structure and organization²².'

'Organization' and 'Skill', in the context of the above classification, make the 'implicit' knowledge, and 'Information' is the carrier of 'explicit' knowledge. The taxonomy of knowledge into 'information', 'skill' and 'organization' is also consistent with the classification of the method of learning into 'formal', 'informal' and 'nonformal'. The interaction between the 'methods of learning' and the different 'aspects of knowledge' will be discussed in detail in another report entitled 'Social Innovation'. The remainder of this report, however, concentrates on the 'transformation of information.'

Before leaving this chapter, we must remind ourselves that none of the classifications for knowledge discussed earlier provides a direct reference to "idea". 'What is the relationship between idea and knowledge?' This is another challenging topic, which needs much attention and study. If the analogy between idea and information is useful, let us assume, at least temporarily, that 'information' and 'idea' are comparable.

INFORMATION TRANSFORMATION

Each and every industry needs knowledge to be able to perform its required activities; without knowledge there could be no production. This assertion is applicable to all aspects of production; for instance, manufacturing, agriculture, and distribution.

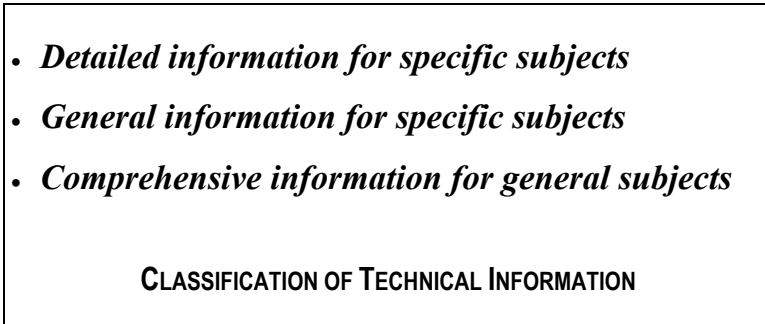
Information, based on its disciplines, may further be categorized into the following main classes, although the borders between these classes are fuzzy, at best:

- Technical information
- Marketing and sales information
- Leadership, management and administration information
- Learning and human resources development information
- Financial and accounting information

The transformation of information, with which this section deals, concentrates on technical information. However, technical information is not confined to engineering or manufacturing. Indeed, finance, marketing or management, depending on the nature of a business, may also be considered as the core of its technical informatio.

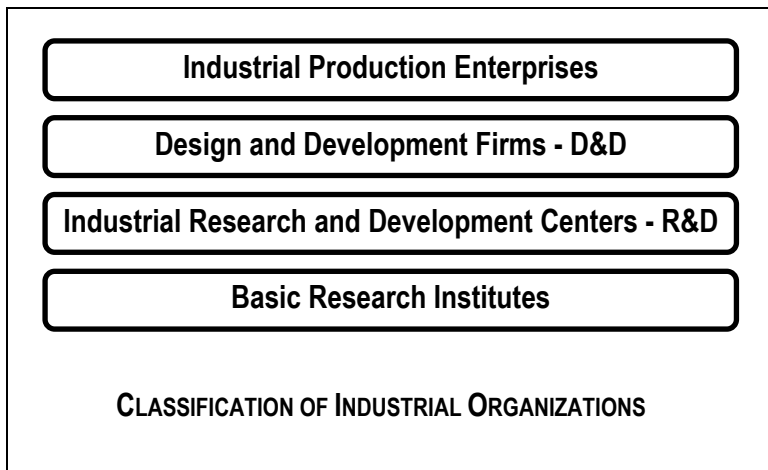
Our knowledge about the transformation of information is much less than our knowledge about the transformation of material and energy. Two centuries ago we had also very limited knowledge about the transformation of energy. Articulating the process of information is probably more difficult than exploring the process of transferring one type of energy to another. Unlike energy, which is a natural phenomenon, information is a human phenomenon: human beings are the source

of all information. In addition to generation, the processing and development of information are also mainly human endeavors. Ultimately, a comprehensive understanding of the process of 'information transformation' depends on our understanding of the architecture of knowledge. A better understanding of the transformation of information, however, will contribute to a greater knowledge of the 'architecture of knowledge'. It would appear that to achieve this goal, we have a long way ahead of us. However, we must begin this journey, and better sooner than later.



To facilitate the organization of the process, technical information is being classified into three main groups, as in the adjacent table. I should emphasize that this hierarchical taxonomy for information transformation is arbitrary and overlaps exist between the above groups of information. This classification,

however, may be used to develop the transformation of information.



Industrial organizations, irrespective of their size or activity, deal in one way or the other with the process of information. Consistent with the classification of information, industrial organizations, according to their role in the process of information, are classified into four main groups, depicted in the next diagram.

The combination of the two classifications for technical information and industrial organizations establishes a configuration between the industrial organizations' role in the transformation of information, as in the next diagram.

Industrial Production Enterprises

↑ ↑ ↑
Detailed information for specific subjects
↑ ↑ ↑

Design and Development Firms - D&D

↑ ↑ ↑
General information for specific subjects
↑ ↑ ↑

Industrial Research and Development Centers -

↑ ↑ ↑
Comprehensive information for general subjects
↑ ↑ ↑

Basic Research Institutes

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¹ Last Update: April 11, 1999