

# Data, Information, Knowledge, Wisdom: A Doubly Linked Chain?

Syed Ahsan

[ahsansyedmuhammad@yahoo.com](mailto:ahsansyedmuhammad@yahoo.com)

Abad Shah

[ababshah@uet.edu.pk](mailto:ababshah@uet.edu.pk)

Research and Development Center of Computer Science  
University of Engineering and Technology, Lahore

## Abstract

*In knowledge management literature it is often pointed out that it is important to distinguish between data, information and knowledge. The generally accepted view sees data as simple facts that become information as data is combined into meaningful structures, which subsequently become knowledge as meaningful information is put into a context and when it can be used to make predictions. This view sees data as a prerequisite for information, and information as a prerequisite for knowledge. In this paper, we give a detailed review of various definitions and explanations of DIKW (Data, Information, Knowledge, Wisdom) hierarchy. We will try to emphasize that the DIKW hierarchy needs to be explored further as its definition and understanding depends upon the context and domain of application. We will also discuss the inverted hierarchy that shows that data emerges only after we have information, and that information emerges only after we already have knowledge.*

Key Words: DIKW, understanding, patterns, relationships, domain of application, Ackoff

## Introduction

We, as intelligent beings, are in need and pursuit of knowledge. This is achieved by observing, perceiving and experiencing different phenomenon. This information/knowledge must be recorded and represented for usage and possible communication with contemporaries and future generations. The representation of

information and knowledge and the very understanding of its nature is therefore a very important issue [1]. Social, economical, political and technological developments have changed the way people look at events and facts and manipulate them [7]. Data is increasingly being seen from the perspective of the user and the application as it now it is possible to analyze large amounts of data in a meaningful way to generate information through ever increasing computational power of computers [3]. Data and information can be integrated to generate knowledge. The user perspective and increasingly complex applications, for example Bioinformatics and Semantic Web, are changing the ways of defining and looking at Data, Information, Knowledge and even Wisdom.

## The Changing Perspective

We are led to think about Data, Information, Knowledge, and Wisdom as we explore the capabilities and limitations of our mind and the tools we have to process the stimuli we receive from our environment [8]. The ever increasing power of computers has made it possible to define Data, Information, and Knowledge at a higher level of abstraction. In the early history of using computers to do business data processing, computers were data processing machines[3]. There were lots of workshops and courses on data

processing. "Raw data" was processed to produce reports that were then analyzed by management to make management decisions. Hourly time sheets of workers were processed to produce payroll checks and summary reports on employee costs. Later came the idea of computers processing data to produce information. Payroll data can be put together with other cost data, sales data, and so on to produce information about which products are most profitable. The huge collection of raw data can be processed into reports that facilitate high level management decisions. Computer Science Departments became Computer and Information Science Departments. Terms such as Information Technology (IT) and Information and Communication Technology (ICT) arose because they better described the computer field. In more recent years, businesses and others have worked to use computers to process information so that it becomes or is closely similar to knowledge [6]. Knowledge in a person's head is used for posing and solving problems, posing and answering questions, defining decision making situations and making decisions, posing tasks to be accomplished and accomplishing the tasks, and so on. Nowadays, computers make lots of decisions without human intervention. That is, they receive data as input and they process it in a manner that produces decisions and actions as output. When a human does this, we talk about the level of knowledge, skill, and intelligence that the person has.

We can argue that Data, Information and knowledge are relative concepts and what is called knowledge can be considered as information (data) on a higher, more abstract domain-of-application level[6].

### The DIKW Hierarchy

"Wisdom is not a product of schooling but of the lifelong attempt to acquire it."

Albert Einstein

Where is the Life we have lost in living?

Where is the wisdom we have lost in knowledge?

Where is the knowledge we have lost in the information?

T.S.Eliot. "The Rock," Faber & Faber 1934

T.S.Eliot could not have anticipated the discussion that has continued from his poetic lines.

Yet in the above lines, he linked wisdom to knowledge and knowledge to information, suggesting that they are interlinked and interdependent. Yet even after 76 years, the very definitions of these terms and the relationships between them are not clear.

In knowledge management literature it has often been pointed out that the relation between knowledge, information and data is important, and often misunderstood. For example, Davenport and Prusak[5] state that:

"Knowledge is neither data nor information, though it is related to both, and the differences between these terms are often a matter of degree...Confusion about what data, information, and knowledge are—how they differ, what those words *mean*—has resulted in enormous expenditures on technology initiatives that rarely deliver what the firms spending the money needed or thought they were getting."[5].

Sometimes it is argued that the problems originate from our insufficient realization that there, indeed, exist considerable differences between data, information, and knowledge. For example, Sveiby maintains that: "Some of the present confusion concerning how to do business in the knowledge era would probably be eliminated if we had a better understanding of the ways in which information and knowledge are both similar and different [7,4]. The widespread but largely unconscious assumption that information is equal to knowledge and that the relationship between a computer and information is equivalent to the relationship between a human brain and human knowledge can lead to dangerous and costly mistakes." [7,4]. In this paper, we will present a model that explicates the relationship between data, information, and knowledge. I will also show that the conventional view on this relationship requires rethinking, and that the traditional hierarchy of data, information, and knowledge needs to be reconsidered. First, we will discuss the conventional view on the hierarchical relationship between data, information, and knowledge.

## The hierarchy of knowledge

Data has commonly been seen as simple facts that can be structured to become information. Information, in turn, becomes knowledge when it is interpreted, put into context, or when meaning is added to it. There are several variations of this widely adopted theme. The common idea is that data is something less than information, and information is less than knowledge. Moreover, it is assumed that we first need to have data before information can be created, and only when we have information, knowledge can emerge[2].

A representation of this view is shown in Figure 1. This figure adds wisdom as another type of knowledge.

In Figure 1, data are assumed to be simple isolated facts. When such facts are put into a context, and combined within a structure, information emerges. When information is given meaning by interpreting it, information becomes knowledge. At this point, facts exist within a mental structure that consciousness can process, for example, to predict future consequences, or to make inferences. As the human mind uses this knowledge to

choose between alternatives, behavior becomes intelligent. Finally, when values and commitment guide intelligent behavior, behavior may be said to be based on wisdom.

### Data

1: factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation <the data is plentiful and easily available.>

2: information output by a sensing device or organ that includes both useful and irrelevant or redundant information and must be processed to be meaningful.

### Information

(1): knowledge obtained from investigation, study, or instruction (2) : intelligence, news (3) : facts, data.

### Knowledge

: the range of one's information.

### Wisdom

1 accumulated philosophic or scientific learning: Knowledge.

2. wise attitude or course of action.

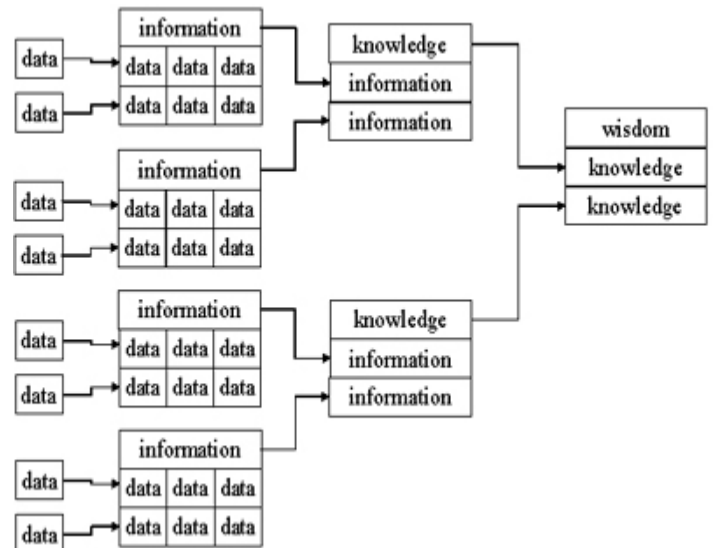


Figure 1: Building on data in the Wisdom Hierarchy.

According to these definitions, “data” is the basic unit of “information,” which in turn is the basic unit of “knowledge,” which itself is the basic unit of “wisdom.” So, we have four levels in our understanding and decision-making hierarchy. The whole purpose in collecting data, information, and knowledge is to be able to make wise decisions. However, if the data sources are flawed, then in most cases the decisions will also be flawed.

As illustrated, “packages” are passed from one level to next. The “wisdom” level has all the required components—data, information, and knowledge—to make wise decisions. Of course, decisions can be made at all levels, depending on the outcome and conditions that exist.

According to Russell Ackoff[7], a systems theorist and professor of organizational change, the content of the human mind can be classified into five categories: Data, Information, Knowledge, Understanding and Wisdom. Ackoff adds another level i.e., understanding between knowledge and wisdom. He indicates that the first four categories relate to the past; they deal with what has been or what is known. Only the fifth category, wisdom, deals with the future because it incorporates vision and design. With wisdom, people can create the future rather than just grasp the present and past. But achieving wisdom isn't easy; people

must move successively through the other categories. A further elaboration of Ackoff's [7] definitions follows:

**Data** is raw. It simply exists and has no significance beyond its existence (in and of itself). It can exist in any form, usable or not. It does not have meaning of itself. In computer parlance, a spreadsheet generally starts out by holding data.

**Information** is data that has been given meaning by way of relational connection. This "meaning" can be useful, but does not have to be. In computer parlance, a relational database makes information from the data stored within it.

**Knowledge** is the appropriate collection of information, such that it's intent is to be useful. Knowledge is a deterministic process. When someone "memorizes" information (as less-aspiring test-bound students often do), then they have amassed knowledge. This knowledge has useful meaning to them, but it does not provide for, in and of itself, an integration such as would infer further knowledge. For example, elementary school children memorize, or amass knowledge of, the "times table". They can tell you that  $2 \times 2 = 4$  because they have amassed that knowledge (it being included in the times table). But when asked what is  $1267 \times 300$ , they can not respond correctly because that entry is not in their times table. To correctly answer such a question requires a true cognitive and analytical ability that is only encompassed in the next level... understanding. In computer parlance, most of the applications we use (modeling, simulation, etc.) exercise some type of stored knowledge.

**Understanding** is an interpolative and probabilistic process. It is cognitive and analytical. It is the process by which I can take knowledge and synthesize new knowledge from the previously held knowledge. The difference between understanding and knowledge is the difference between "learning" and "memorizing". People who have understanding can undertake useful actions because they can synthesize new knowledge,

or in some cases, at least new information, from what is previously known (and understood). That is, understanding can build upon currently held information, knowledge and understanding itself. In computer parlance, AI systems possess understanding in the sense that they are able to synthesize new knowledge from previously stored information and knowledge.

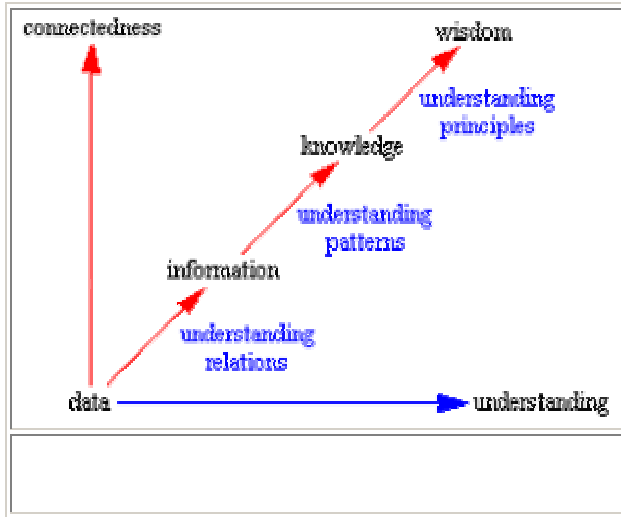
**Wisdom** is an extrapolative and non-deterministic, non-probabilistic process. It calls upon all the previous levels of consciousness, and specifically upon special types of human programming (moral, ethical codes, etc.). It beckons to give us understanding about which there has previously been no understanding, and in doing so, goes far beyond understanding itself. It is the essence of philosophical probing. Unlike the previous four levels, it asks questions to which there is no (easily-achievable) answer, and in some cases, to which there can be no humanly-known answer period. Wisdom is therefore, the process by which we also discern, or judge, between right and wrong, good and bad. I personally believe that computers do not have, and will never have the ability to possess wisdom. Wisdom is a uniquely human state, or as I see it, wisdom requires one to have a soul, for it resides as much in the heart as in the mind. And a soul is something machines will never possess (or perhaps I should reword that to say, a soul is something that, in general, will never possess a machine).

It has been contended that the sequence is a bit less involved than described by Ackoff [7]. Figure 2 represents the transitions from data, to information, to knowledge, and finally to wisdom, and it is understanding that support the transition from each stage to the next. Understanding is not a separate level of its own.

## Other Definitions and Views

Various people have thought carefully about varying definitions of these four terms and produced their own analysis of the four terms.:

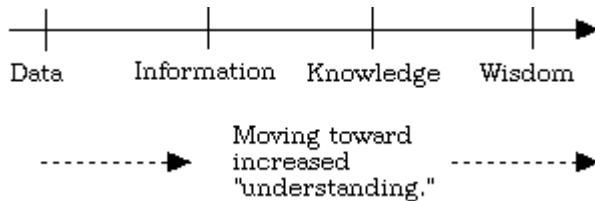
Information consists of data, but data is not necessarily information. Also, wisdom is knowledge, which in turn is information, which in turn is data, but, for example, knowledge is not necessarily wisdom. So wisdom is a subset of knowledge, which is a subset of information, which is a subset of data [1].



**Figure 2. Transition through understanding**

**Arranging the Terms Along a scale**

The terms Data, Information, Knowledge, and Wisdom are sometimes presented in a form that suggests a scale.

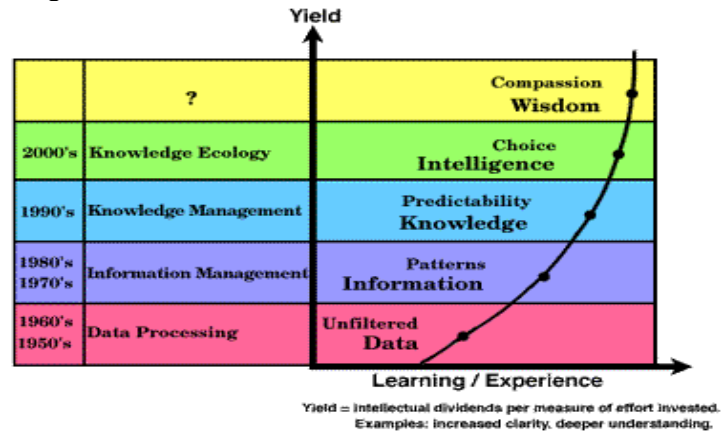


However, in no sense do these four terms define some sort of linear equal-interval scale. Data, information, knowledge, and wisdom form a scale, although a rather peculiar scale. The points on the scale are not closely related even though they are often talked about at the same time. They do, however, help us to discuss the design of some particular system, such as educational system, as well as current and potential uses of computers. For example, we all accept

that computers can be used for the input, storage, processing, and output of data [2]. But, there is considerable disagreement about whether a computer can have knowledge or be knowledgeable--or have wisdom and be wise.

The following summary and chart are quoted from [Designing Knowledge Ecosystems for Communities of Practice](#).

The graph below reflects the learning journey whereby we progressively transform the raw, unfiltered facts and symbols into information, knowledge, and eventually into intelligence and wisdom.



The following three definitions are quoted from Godbout (January 1999)[4].

Data constitutes one of the primary forms of information. It essentially consists of recordings of transactions or events which will be used for exchange between humans or even with machines. As such, data does not carry meaning unless one understands the context in which the data was gathered. A word, a number or a symbol can be used do describe a business result, inserted in a marriage contract or a graffiti on the wall. It is the context which gives it meaning, and this meaning makes it informative.

Information extends the concept of data in a broader context. As such it includes data but it also includes all the information a person comes in contact with as a member of a social organization in a given physical environment. Information like data, is carried through symbols. These symbols have complex structures and rules. Information therefore comes in a variety of forms such as writings, statements, statistics, diagrams or charts. Some information

theorists insist on the concept of form as the differentiating factor and the essence of information.

Where does knowledge fit in this scenario? Information becomes individual knowledge when it is accepted and retained by an individual as being a proper understanding of what is true [3] and a valid interpretation of the reality. Conversely, organizational or social knowledge exists when it is accepted by a consensus of a group of people. Common knowledge does not require necessarily to be shared by all members to exist, the fact that it is accepted amongst a group of informed persons can be considered a sufficient condition. This is also true of «public domain» knowledge. The fact that it is readily available in writing or published material does not entail that everybody should be knowledgeable about it to meet the condition of being "common knowledge".

It appears that one of the issues in defining the terms data, information, knowledge, and wisdom is the role of understanding and meaning making. One can memorize data, and parrot it back. One processes data (organizes it into meaningful chunks?) to produce information. Parroting such chunks sounds more like being educated--but this can be done with little understanding or ability to make use of the information. Knowledge is a step further on the scale. It involves understanding and ability to make use of the data and information to answer questions, solve problems, make decisions, and so on. Wisdom has to do with using one's knowledge in a responsible (wise) manner.

We can define wisdom as the application of intelligence and experience toward the attainment of a common good. This attainment involves a balance among (a) intrapersonal (one's own), (b) interpersonal (other people's), and (c) extrapersonal (more than personal, such as institutional) interests, over the short and long terms. Thus, wise people look out not just for themselves, but for all toward whom they have any responsibility[2].

Ilkka Tuomi, in his paper suggested that the underlying view in the conventional description of the construction of knowledge

is somewhat similar to using letters as atoms for building words that are subsequently combined to meaningful sentences, that the value of the various forms of data-information-knowledge increase through learning. In this process data is increasingly "refined" [4]. This view is shared by most authors, although the details differ. For example, Davenport and Prusak[5] state that:

"Data is a set of discrete, objective facts about events...Data describes only a part of what happened; it provides no judgment or interpretation and no sustainable basis of action...Data says nothing about its own importance or relevance."

According to Davenport and Prusak, however, data turns into information as soon as it is given meaning. Information must inform: "it's data that makes a difference...Unlike data, information has meaning ...Data becomes information when its creator adds meaning" [5].

Davenport and Prusak maintain that "knowledge derives from information as information derives from data" [5]. They view knowledge as refined information, in which human cognition has added value. Information becomes knowledge through cognitive effort. For example, the human mind can compare information about a specific situation with other situations it has known, anticipate implications for decisions and actions, relate one bit of knowledge to other bits of knowledge, and share interpretations with other people [8]. As a result, and unlike data and information, knowledge contains judgment. According to Davenport and Prusak, "values and beliefs are integral to knowledge, determining in large part what the knower sees, absorbs, and concludes from his observations"[5].

## The Inverted Pyramid

It is argued that it should not be difficult to recognize that the hierarchy of data-information- knowledge should be turned the other way around[4]. Depending upon the Domain of Application, information can be 'reversed processed' or 'taken apart', to become data. As Bill Gates put it, 'Every year, better methods are being devised to quantify information... in to quadrillions of

atomistic packets of data”. Data emerges last—only after there is knowledge and information available. There are no “isolated pieces of simple facts” unless someone has created them using his or her knowledge. Data can emerge only if a meaning structure, or semantics, is first fixed and then used to represent information. This happens, for example, when information is stored in a semantically well defined computer database[4]. In that special case, we have to de-contextualize knowledge, and structure it according to pre-defined semantics into “isolated” and independent database entries. Ideally, the data so produced can be completely detached from any meaning, so that it can be automatically processed using a computer program. Data, therefore, exist only as a solution to a practical problem: how to dissect information into two forms that can be modeled, represented, and processed separately[4]. This also explains why database architects have believed that it is extremely important that database structure has an underlying well-defined semantics, and that the database content should be represented in a standard normal form. However, these requirements do not arise from any knowledge processing requirements as such; instead, they are artifacts created by information processing machines that rely on meaningless manipulation of syntactical structures. Data, therefore, does not become information after meaning is added to it. On the contrary, data is created from information by putting information into a pre-defined data structure that completely defines its meaning[2]. Instead of being raw material for information, data emerges as a result of adding value to information by putting it into a form that can be automatically processed.

## Conclusion

In this paper, the commonly used hierarchy of data-information-knowledge was analyzed, and it was shown that the definitions of these terms is relative and context dependent. It is important to further explore these domains and the interrelationships between them and the

traditional hierarchy of data, information, and knowledge needs to be reconsidered if we want to develop efficient and cost effective knowledge based systems. For example, Davenport and Prusak state that: “Knowledge is neither data nor information, though it is related to both, and the differences between these terms are often a matter of degree...Confusion about what data, information, and knowledge are—how they differ, what those words *mean*—has resulted in enormous expenditures on technology initiatives that rarely deliver what the firms spending the money needed or thought they were getting.” [5]. The problems sometimes originate from our insufficient realization that there, indeed, exist considerable differences between data, information, and knowledge. Information can be created only after there is knowledge, and data emerges as a by-product of cognitive artifacts that assume the existence of socially shared practice of using these artifacts.

## References

- [1] Bellinger, Gene; Castro, Durval; and Mills, Anthony. , Date, Information, Knowledge, and Wisdom. Accessed 5/03/2006 <http://www.outsights.com/systems/dikw/dikw.htm>
- [2] Godbout, Alain J. (January 1999). Filtering Knowledge: Changing Information into Knowledge Assets. Journal of Systemic Knowledge Management., Accessed 01/02/2006 <http://www.iste.org/L&L/26/8/summaries.html#Editorial>
- [3] Sternberg, Robert J. (November 13, 2002). Teaching for Wisdom in Our Schools. Education Week. Accessed 01/02/2006 <http://www.edweek.com/ew/ewstory.cfm?slug=11sternberg.h22 slug=11sternberg.h22>
- [4] Ilkka Tuomi, Proceedings of the 32nd Hawaii International Conference on System Sciences – 1999
- [5] Davenport, T.H. and L. Prusak (1998). Working Knowledge: How Organizations Manage What They Know. Harvard Business School Press, Boston, MA.
- [6] Davenport, T.H. (1997). Information Ecology: Mastering the Information and Knowledge Environment Oxford University Press, New York..
- [7] Ackoff, R.L.,(1989). "From Data to Wisdom", Journal of Applied Systems Analysis, Volume 16, 1989.
- [8] Bateson, Gregory, (1988). Mind and Nature: A Necessary Unity, Bantam, 1988.