The Knowledge Pyramid: the DIKW Hierarchy†

Martin Frické

University of Arizona, School of Information, Tucson, AZ 85721, U.S.A.
<mfricke@u.arizona.edu>

Martin Frické is a full professor in the School of Information, at the University of Arizona, in the United States. His long-term research interest involves the intersection between the organization of knowledge, logic, and processing by computer. Currently he is working on blockchain technologies and their relation to distributed trust and recorded information.

Frické, Martin. 2019. "The Knowledge Pyramid: the DIKW Hierarchy." *Knowledge Organization* 46(1): 33-46. 93 references. DOI:10.5771/0943-7444-2019-1-33.

Abstract: The data-information-knowledge-wisdom (DIKW) hierarchy or pyramid is a model or construct that has been used widely within information science and knowledge management. The nature of the pyramid is explained, and its historical origin is described. The conceptual components of the pyramid—i.e. data, information, knowledge, and wisdom—are given brief explication. Some modern developments, criticisms, and rebuttals of the DIKW Pyramid are described. Nowadays, the DIKW Pyramid would generally be considered to be unsatisfactory. The arguments and reasoning behind this conclusion are sketched. It is claimed that two more concepts, document and sign, are necessary to provide a fruitful theoretical frame for knowledge organization.

Received: 5 June 2018; Accepted 13 July 2018

Keywords: knowledge, wisdom, data, information

† Derived from the article of similar title in the ISKO Encyclopedia of Knowledge Organization, Version 1.0; published 2018-06-07, last edited 2018-06-13. Article category: Theoretical concepts. The encyclopedia entry uses some passages of background material previously available as part of Frické (2009). The editor of IEKO, Birger Hjørland, has contributed with modifications of the original manuscript, including modifications that are substantial.

1.0 Introduction

Seeing information in terms of a data-information-knowledge–wisdom (DIKW) hierarchy or pyramid is commonplace (Bates 2005; Frické 2009; Rowley 2007; Zins 2007; Baskarada and Koronios 2013).

Figure 1. The Knowledge Pyramid.

As Rowley writes (2007, 163)

> The hierarchy referred to variously as the "Knowledge Hierarchy," the "Information Hierarchy" and the "Knowledge Pyramid" is one of the fundamental, widely recognized and 'taken-for-granted' models in the information and knowledge literatures. It is often quoted, or used implicitly, in definitions of data, information and knowledge in the information management, information systems and knowledge management literature.

Rowley (2007) offers a detailed exegesis of just how widespread this view is, and of the similarities and differences between the writers' statements. There also have been wide-ranging discussions on the JESSE listserv (Wallace 2005) and on the Knowledge Management for Development Wiki (KM4DEV 2012). Further, Zins (2007) has surveyed forty-five leading researchers on the topic and produced 130 definitions of data, information, and knowledge.

One issue that arises immediately is that there is not a single concept of information, nor, for that matter, a single concept of data, or of knowledge. Floridi (2011) describes the concepts of information as forming an archipelago; we might say that the concepts of data and the concepts of knowledge also form archipelagos. It is unclear whether the fourth concept, the concept of wisdom is single or many; the uncertainty here is primarily because, comparatively speaking, there has been nowhere near as much research and analysis on wisdom as there has on the other three families of concepts.

This plethora suggests that it would be prudent to focus on a core of the different accounts. Also, the present article has as its topic "the knowledge pyramid." Certainly, the component concepts of that pyramid are of interest in themselves—indeed, data, information, and knowledge have encyclopedia entries of their own elsewhere[1]—but here it is the relationships between the concepts that are central.

Historically, the strands leading to DIKW come from a mention by the poet T. S. Eliot[2] and, separately, from research from Harland Cleveland and the systems theorists Adler, Ackoff, and Zeleny (Rowley 2007; Sharma 2008; Cleveland 1982; Lambe 2011; Williams 2014). The main views are perhaps best expressed in the traditional sources of Adler (1985), Ackoff (1989), and Zeleny (1987).

There is another preliminary issue. DIKW arises in two separate contexts: managing information in business process settings and discussing data, information etc. as logico-conceptual constructs demanding analysis and explication. The former is certainly important as a real-world practical challenge, and models, including DIKW and its variations, have a central role to play (Bedford and Lewis 2015; Duffield and Whitty 2015; Roberts 2015; Williams 2014). The latter context is more the province of theoretical researchers in library and information science (Dinneen and Brauner 2015; Van der Veer Martens 2015; Yu 2015).

The present article tends to be logico-conceptual in its approach (although some lead-in citations are given to the business process literature).

2.0 What is the core account of DIKW?

What, at the heart, is DIKW and how does it work? It is suggested that there is a hierarchy built on the foundation of data. Ackoff (1989, 3) explains it top down: "Wisdom is located at the top of a hierarchy of types … Descending from wisdom there are understanding, knowledge, information, and, at the bottom, data. Each of these includes the categories that fall below it." Ackoff includes a fifth level, "understanding;" typically, that is not done (but see Bawden and Robinson 2015).

It is supposed that the many and various items of the world have properties that can be observed. And data is the symbolic representation of these observable properties (Rowley 2007, Section 5.2 Defining Data). The prime example of data and data acquisition is provided by automatic instrument systems; an unmanned weather station, for instance, may record daily maximum and minimum temperatures; such recordings are data. Ackoff writes (1989, 3): "Data are symbols that represent properties of objects, events and their environments. They are products of observation. To observe is to sense. The technology of sensing, instrumentation, is, of course, highly developed."

Next up the hierarchy is information. This is relevant or usable or significant or meaningful or processed data (Rowley 2007, Section 5.3 Defining Information). The vision is that of a human asking a question beginning with, perhaps, "who," "what," "where," "when," or "how many" (Ackoff 1989, 3), and the data is processed into an answer to an enquiry. When this happens, the data becomes "information." Data itself is of no value until it is transformed into a relevant form. In consequence, the difference between data and information is functional, not structural (Ackoff 1989, 3).

Information can also be inferred from data—it does not have to be immediately available. For example, were an enquiry to be "what is the average temperature for July?" there may be individual temperatures explicitly recorded as data but perhaps not the average temperature; however, the average temperature can be calculated or inferred from the data about individual temperatures. The processing of data to produce information often reduces that data (because, typically, only some of the data is relevant). Ackoff writes (1989, 3): "Information systems generate, store, retrieve, and process data. In many cases their processing is statistical or arithmetical. In either case, information is inferred from data."

Information is relevant data, together with, on occasions, the results of inferences from that relevant data. Information is thus a subset of the data, or a subset of the data augmented by additional items inferred or calculated or refined from that subset.

The next category is knowledge. Users of this hierarchy often construe knowledge as know-how or skill, rather than knowledge in the sense of the know-that of propositional knowledge. Ackoff suggests (1989, 4) that know-how allows an agent to promote information to a controlling role—to transform information into instructions: "Knowledge is know-how, for example, how a system works. It is what makes possible the transformation of information into instructions. It makes control of a system possible. To control a system is to make it work efficiently."

Further up the hierarchy comes wisdom—a category that seems always to have been given only limited discussion (but see Dalal (2012); Hoppe et al. (2011); and Liew 2013)). While wisdom is traditionally taken to be a layer in the hierarchy, few authors discuss it or use it. This may be because it is not required for the problems they address (Rowley 2007).

Ackoff, while not really defining wisdom, does explain how it works (1989, 9):

> Wisdom adds value, which requires the mental function we call judgement .… The value of an act is never independent of the actor … [ethical and aesthetic values] are unique and personal … wisdom-generating systems are ones that man will never be able to assign to automata. It may well be that wisdom, which is essential to the effective pursuit of ideals, and the pursuit of ideals itself, are the characteristics that differentiate man from machines.

An important point is being made here. In some sense or other, the three lower layers of the DIKW pyramid can, or might, be recorded and manipulated by computers. However, in Ackoff's view, wisdom requires a human actor, and that actor is outside the DIKW system and outside the realm of computer operations. So, wisdom cannot be placed on the top of the DIKW pyramid as a component of an autonomous logico-deductive structure, rather wisdom bridges the lower levels to human beings and their actions.

Ackoff concludes (1989, 3) with some numbers, seemingly produced out of thin air, "on average about forty percent of the human mind consists of data, thirty percent information, twenty percent knowledge, ten percent understanding, and virtually no wisdom."

The DIKW suggests that there are more data than information in the world, more information than knowledge and more knowledge than wisdom.[3]

3.0 Background concepts

The core concepts in the DIKW-model are data, information, knowledge, and wisdom. This section will present some of the commonly used explications of these notions. In Section 3.1. the concepts of documents [see http://www.isko.org/cyclo/document] (records, recordings, inscriptions, representational artefacts, informative objects etc.) is introduced, and in the conclusion (Section 7), we will briefly consider the absence of another concept: sign.

3.1 Data

We will assume that data have, or can have, linguistic representation as true or false statements (The reasons for making this assumption will become clear as the discussion develops. To anticipate: it is required for logic and reasoning, for epistemology, and for Bayesianism).

Accounts of the concept of data have a long and varied history (Furner 2016; Rowley 2007; Zins 2007). And those accounts often intertwine with accounts of evidence and accounts of facts. Data is "given," or a datum is "a given." As Machlup writes (1983, 646):

> Data are the things given to the analyst, investigator, or problem-solver; they may be numbers, words, sentences, records, assumptions—just anything given, no matter what form and of what origin. This used to be well known to scholars in most fields: some wanted the word data to refer to facts, especially to instrument-readings; others to assumptions. Scholars with a hypothetico-deductive bent wanted data to mean the given set of assumptions; those with an empirical bent wanted data to mean the records, or protocol statements, representing the findings of observation, qualitative or quantitative.

Seemingly, being a "given" really amounts to possessing two features: truth and certainty. Maybe data should be true, and maybe data should be known for certain to be true.

What about the first feature, its truth? We definitely talk of mistaken data, incorrect data, invalid data, wrong data, etc. all the time. But is mistaken data still data? Strictly speaking it is not (just as counterfeit money is not money). When we discover that a specific "datum" is mistaken, we can and should correct our records of it. The reason we do this is the supposition of success (that is why we make all the fuss about how we collect data and make all the fuss about reliability and validity). Data is used for various purposes, to test theories and be evidence for them, to determine parameters, to answer questions, to be input for calculations, etc. These roles pre-suppose the truth of data. Data needs to be true.

The second presumed feature of data, its certainty, fails, or requires modification. Data is not known for certain to be true. Data is fallible and conjectural. This conclusion follows from the philosophical result that there is no certain knowledge. All knowledge is conjectural (Musgrave 1993). That we are fallibilists means that we never know (know for certain) that data is true, but, nonetheless, data needs to be true (see also Haack 1999; Musgrave 1993).

Data is akin to evidence. Data often is evidence. There are theories and theories of evidence. A central, widespread, and maybe the best, current theory of evidence is Bayesianism (Howson and Urbach 2006; Jaynes 2003). Under Bayesianism, evidence has to be true. Bayesians are fallibilists. They know that there is a difficulty in knowing (for certain) what is true. So, they make the requirement that evidence is assumed to be a given (relative to the context of discussion and particular Bayesian inferences).

Data is also akin to facts or (true) factual statements. Once again there are theories and theories of facts, but it is pretty mainstream to adopt a refined common sense and take it that facts are what true statements assert. Under the theory of data offered here, data is indeed similar to facts.

There are some points to be made about the logical form and logical strength of data statements. The temperature at a particular time on a particular day is a singular piece of data; it is a particular fact; it is a logical atom. There might be several such atoms, and these can be combined in various ways using the standard operations of, perhaps, first order logic (FOL) (Sowa 2000), i.e., using "and," "or," "not" etc. to make more statements. But there are also universal statements, such as "every day the maximum temperature is above 50 degrees." Many, indeed very many, universal statements will be true (and so are candidates for being data under the characterization of data given thus far). But these universal statements are stronger, from a logical point of view, than atoms or compounds of atoms, and thus it is more difficult to be assured about their truth. Crudely, our knowledge of the universal is more fallible than our knowledge of the singular. A fallibilist would prefer to be accepting as data the truth of a judgment of the form "there is a white X" to one of the form "all Xs are white." It is possible to give a logical characterization of this feature of how strong or how weak data statements should be. Karl Popper did it with his notion of "basic statement" (Popper 1959). Basic statements, logical atoms and compounds of atoms, can be expressed by existential-conjunctive (EC) logic. EC logic is first order logic (FOL) with its logical operators restricted to existential quantifiers and conjunction only (i.e., it does not have negation, implication, disjunction, functions, or the universal quantifier). EC logic is a fragment of FOL, a fragment which focuses on positive assertions. EC logic captures concrete facts. This fits neatly with Ackoff's views. Ackoff wrote (1989, 3) "Data are symbols that represent properties of objects, events and their environments."

EC logic does this. There is also a technical result of import here. EC logic captures exactly those statements held in ordinary computer databases. (Sowa 2000, 163): "Every database used by [SQL, Prolog, Microplanner]—as well as every commercial database, whether relational, hierarchical, or object-oriented implements the existential-conjunctive subset of logic."

And statements of EC logic can be put into a relational database, say, merely by adding the appropriate n-tuple for each atom (i.e., for each concrete fact) (Codd 1970). EC logic is also widely used in artificial intelligence, in theorem proving, and in machine learning. Thus, EC logic sits comfortably with the modern idea of reasoning from big data.

Data might be of a number of different kinds. There can be empirical data, for example, about daily temperatures at a particular place and time. There can be non-empirical data, for example, the mathematical data that there are four prime numbers between ten and twenty. There can be non-empirical data in the context of fiction, for example, it is a datum that Sherlock Holmes lived at 221B Baker Street. And there are many more types of data besides (see, for example, Kaase 2001). As a source from the literature, Nielsen and Hjørland (2014) argue that data is contextual and related to human activities, then there are many kinds of human activities, ergo there are many kinds of data. To keep the present discussion manageable, it will focus on plain empirical data about the world.

The essence of knowledge organization, or knowledge management, is that they deal with documents (or records, recordings, inscriptions, informative objects and representational artefacts, etc.). Documents are culturally developed ways of communicating knowledge, information and data, and their different kinds or genres are specialized tools for such communication. Library and information science (http://www.isko.org/cyclo/lis) and knowledge organization (http://www.isko.org/cyclo/knowledge_organization) is mainly about classifying, indexing, and retrieving documents, and such activities cannot be adequately understood and researched without the concept of document.

This invites the suggestion that the notion of data, of interest to knowledge organization, in the context of DIKW, is that of anything recordable in a database in a semantically and pragmatically sound way. The semantics require that the recordings be understood as true or false statements. The pragmatics require that we favor recording what seem to be concrete facts, i.e., singular and relatively weak statements, and that interpreted recordings be true statements (and we have to use conjectures on this). Still, it is important to consider that data are constructed from a certain perspective and for a certain purpose that put limits to its use in other contexts.

3.2 Information

What about information? Information can be, and has been, construed to be

- knowledge, personal or public,
- the physical manifestation of knowledge,
- a state or structure transformer,
- knowledge or belief new to subject,
- a member of the data-information-knowledge-(wisdom/understanding) hierarchy,
- a construct in thermodynamics,
- entropy or negentropy,
- reduction in uncertainty,
- signal information,

– content or semantic information,
– truthlike information,
– patterns,

and, many more things besides (Bates 2005, 2006; Belkin 1978; Boell and Cecez-Kecmanovic 2011, 2015; Capurro and Hjørland 2003; Frické 1997; Furner 2014; Ma 2012; Robinson and Bawden 2014).

As Floridi writes (2004, 117):

> Information is notoriously a polymorphic phenomenon and a polysemantic concept so, as an explicandum, it can be associated with several explanations, depending on the level of abstraction adopted and the cluster of requirements and desiderata orientating a theory.

Working broad-brush, these accounts of information can be characterized as being syntactic or semantic. Syntactic information, such as Shannon's signal information, Chaitin's Kolmogorov complexity, thermodynamic entropy, Fisher information, etc. (Chaitin 1987; Pierce 1980; Shannon and Weaver 1949), have been considered important for information science but has a controversial status (cf., Hjørland 2018, 239-42).[4] In the context of the DIKW pyramid, with the desire to talk about data, knowledge, and wisdom, syntactic information is not the concept in use. The DIKW pyramid is not about juggling and permuting inscriptions in an accurate and efficient way. Instead the concept employed is semantic information. This is the concept where attention is paid to the meaning and truth, and other semantic properties, of the recorded marks.

Within accounts of semantic information there are many theories and a number of live issues. Need information be true? Is misinformation and disinformation real information? Need information be new to the user? Must someone be "informed" by it for it to be information? There are open questions about which reasonable researchers can disagree. Even so, a proposal can be placed on the table. The focus of interest in this context is both information science and data. Librarians, information scientists and people associated with knowledge organization often use "knowledge" and "information" as synonyms, and they need not be widely wrong to do so.[5] Information can be taken to be the recorded counterpart of true propositions, i.e., so-called "weak knowledge" or "weak public knowledge."

The concepts of knowledge, weak knowledge, and weak public knowledge will be explained in the next section. Suffice it to say, for the present, weak public knowledge are community held views which are true.

The interim conclusions are these: there are many different senses of "information," there are even many different senses of "information" in use in information science. It is not the case that one of these senses is good, and all purpose, and the others deficient. But, both in information science and elsewhere, there are different problems and different contexts where these different notions of information come into play. As Shannon wrote (1993, 180 emphasis original)

> *The word "information" has been given different meanings by various writers in the general field of information theory. It is likely that at least a number of these will prove sufficiently useful in certain applications to deserve further study and permanent recognition.* It is hardly to be expected that a single concept of information would satisfactorily account for the numerous possible applications of this general field.

And, when the focus is on DIKW, so-called "weak knowledge" may prove suitable as an account of information.

3.3 Knowledge

A distinction with knowledge is that between knowledge-that and knowledge-how. Knowledge, in the sense of a knowledge base or knowledge within traditional philosophy, is just a collection of propositional "know-that's;" for example, a person might know "that" the Eiffel Tower is in Paris and know "that" the Channel Tunnel connects England and France. Additionally, using a different concept, that very same person might know "how" to ride a bicycle. This latter is a different kind of knowledge, it is skill or "know-how" (Carr 1979; Ryle [1946] 1971; Snowdon 2003).

In philosophy, personal know-thats have been given a basic explication in terms of justified, true belief (Plato 2017). A person knows that p if, and only if,

> p is true,
> the person believes p, and,
> the person is justified in her belief of p.

This analysis is a proposal in answer to the question "what do I know?," which is a personal question. But there is another know-that epistemological question, namely, "what is known?" and this is seeking an analysis of public knowledge. Typically, the analysis of public knowledge, impersonal knowledge, would be

> p is true,
> p is accepted by the community,
> the community has evidence or justification for p.

While the standard justified-true-belief account of personal knowledge and justified-true-(community-accepted) account of public knowledge are absolutely central and widespread within traditional philosophy (Musgrave 1993), they are by no means universal with modern philosophers. Many contemporary epistemologists make a distinction between strong and weak knowledge; Goldman (1999) is one example. Strong knowledge covers justified-true-beliefs and justified-true-(community-accepted)-statements. Weak knowledge is like strong knowledge except that the justification component is omitted. Thus, weak personal knowledge consists of beliefs which are true, and weak impersonal knowledge consists of community held views that are true. It has been suggested earlier that the concept of weak personal or public knowledge, in its recorded form, is suitable as a view of information.

Ackoff, and the early systems theorists, tend to use a "know-how" concept of knowledge. Examples of know how are that a person knows how to ride a bike or knows how to play chess. There are philosophical accounts of know-how (see, for example, Fantl 2016). Know-how is often analyzed in terms of ability; a person knows how to ride a bike if they have the ability to ride a bike. Another strand that can feed into the analysis is intellectualist vs. anti-intellectualist approaches and this is to do with the extent to which know-how is parasitic, symbiotic, or dependent, upon know-that. An intellectualist might say that, in chess, if a person knows that a pawn can advance two squares on the first move, knows that bishops move diagonally, etc. etc. then that person knows how to play chess. In other words, knowing how to play chess merely amounts to knowing a suitable collection of know-thats. This intellectualist account is much less plausible with a case like riding a bike. Which know-thats, exactly, does a bike rider have to have in order to know how to ride a bike? The bike rider cannot say, nor, seemingly, can anyone else. At this point, the anti-intellectualist might trumpet: know-hows have nothing to do with know-thats. This might be a reasonable conclusion, but the intellectualist is not quite dead yet. The intellectualist can introduce the idea of "tacit" knowledge (Polanyi 1958, 1967). This is knowledge, know-that knowledge, that someone has but which they cannot say, articulate, or put into words. In general, there is plenty of tacit knowledge (though there is a question of whether that concept belongs here). So, the intellectualist might argue that the know-how of a bike rider is dependent on a collection of know-thats, but the know-thats are tacit and difficult to make explicit.

The Ackoff tradition uses know-how and it relates that to ability. DIKW swirls in data and information, which is to suggest that DIKW has a lot of connection at the lower levels with propositions and know-thats. This, in turn, suggests that the systems theories would take an intellectualist view of know-how (that know-how is intimately related to know-that). Finally, this position really requires some use of tacit knowledge.

3.4 Wisdom

That leaves wisdom. The concept of wisdom certainly occupied the ancient Greek philosophers, such as Plato and Aristotle; although it has not been a popular topic of discussion in recent times. There seem to be several different strands to wisdom (Ryan 2013; Sternberg 1990, 2017). A wise person needs to have an understanding of the epistemic status of what he or she knows, i.e., they have to be a fallibilist—Socrates was considered wise largely because all he knew was that he knew nothing. Then, almost in contradiction to this, a wise person has to know, fallibly, plenty. A person that genuinely knows little or nothing, a person with an empty head, is not a wise person. Then this wide knowledge has to be of a certain kind, a kind that applies to the many and varied problems of life. A person may have encyclopedic knowledge of the facts and figures relating to the countries of the world, but that knowledge, of itself, will not make that person wise. The wide knowledge has to be applicable to tricky problems of an ethical and practical kind, of how to act. (Nozick 1989, 269):

> Wisdom is not just one type of knowledge, but diverse. What a wise person needs to know and understand constitutes a varied list: the most important goals and values of life—the ultimate goal, if there is one; what means will reach these goals without too great a cost; what kinds of dangers threaten the achieving of these goals; how to recognize and avoid or minimize these dangers; what different types of human beings are like in their actions and motives (as this presents dangers or opportunities); what is not possible or feasible to achieve (or avoid); how to tell what is appropriate when; knowing when certain goals are sufficiently achieved; what limitations are unavoidable and how to accept them; how to improve oneself and one's relationships with others or society; knowing what the true and unapparent value of various things is; when to take a long-term view; knowing the variety and obduracy of facts, institutions, and human nature; understanding what one's real motives are; how to cope and deal with the major tragedies and dilemmas of life, and with the major good things too.

And the wise person must not only have wide appropriate knowledge, but they must act in accordance with the knowledge they have—they need to use their knowledge when required and not to ignore it by choice or chance.

The DIKW account of wisdom, in its Ackoff version, is reasonably in harmony with this. Ackoff, and his immediate followers, were systems theorists, they were control theorists. Knowledge, was know-how, know how to control the systems. Then wisdom was merely a matter of using that practical know how to achieve appropriate ends.

4.0 Modern developments, variations, and rebuttals of DIKW

There are publications that argue that DIKW should be "top- down." Tuomi (1999) favors inverting DIKW so that it becomes top-down. The argument here is hypothetico-deductivism combined with the theory-ladeness observations (emphasized elsewhere by Hanson (1958) and Kuhn, 1962). The suggestion is that there is no such thing as "raw data," rather all data must have theory in it and thus theory (i.e., knowledge, information) must illuminate data, top down, rather than the other way around, bottom up. Sato and Huang (2015) also emphasize the need for knowledge and information to highlight data, as does Weinberger (2010). Frické (2009) also presents top-down reasoning, but he goes further. He argues that DIKW should be abandoned completely. His position develops from a Popperian fallibilist realism, combined with hypothetico-deductivism and a modesty about humankind's place in reality. He identifies in DIKW an operationalist thread and an inductivist thread—both of which are anathemas to his starting position. Frické reasons that some information is universal in form and as such could not have been derived from data.

There are publications that add or subtract layers from DIKW. Hoppe et al. (2011) suggest omitting wisdom from the DIKW pyramid (to leave a DIK pyramid). Their paper provides an insightful discussion of wisdom and DIKW. They summarize common points in definitions of wisdom (588):

- based on a special kind of knowledge: It is agreed that a certain type of knowledge is needed to develop wisdom, whereas the definite type is hardly described.
- controlled emotion: Wisdom is neither pure rationality, nor pure emotion based; it creates a certain kind of "intuition."
- creativity: Wise solutions often include a novel approach to a problem, a creative interconnection of knowledge and experience that leads to a better performance.
- wise behaviour: The attribute "wise" is mostly awarded to a certain behaviour, seldomly to a person, never to a mere fact.
- connected to special circumstances: A behaviour is not generally wise, but depends on the situation it happens in, the judging observer, the epoche, ...
- peak-performance: Wisdom is a peak performance one can only achieve with a large amount of experience, knowledge and probably with age.

They argue that the concept of wisdom is both an imprecise concept and fuzzy concept. They note, in a way following Ackoff, that wisdom is a different kind or category of thing to data, information, and knowledge. They suggest that it should be removed from the DIKW hierarchy. In contrast, (Pop, Talpos and Prisac 2015) would like DIKW expanded to DIMLAK (data, information, messages, learning, and advanced knowledge).

There are publications that draw DIKW more into management practices. Jennex (2009, 1) suggests that:

> The knowledge pyramid is an artifact of KM [Knowledge Management] processes and not an artifact of reality … the knowledge pyramid is an artificially constructed artifact representing the relationship between DIKW in an organizational KM context.

Jennex argues that DIKW does not stand on its own, rather it exists in the context of organizational learning. He also makes the point that managers or organizations are not interested in knowledge or wisdom in general, rather they are interested in knowledge or wisdom in settings relevant to what they do (Jennex 2009, 4): "Knowledge management is not trying to capture all knowledge or wisdom. Rather, knowledge management targets specific knowledge and wisdom needed by an organization to perform specific tasks."

Müller and Maasdorp (2011) analyze the presumed role of DIKW within knowledge management as a theory of a flow of decisions within an organizational context (1):

> However, we approach information science as a management and organizationally driven field rather than a computationally and information systems oriented one. This means that information theory and the associated versions of communication theory do not explain or shed much light on dynamics that are significant in management and organization. A focus on social science and philosophical ideas of the socially and linguistically embedded nature of knowledge enables us to reflect on organizational processes in a particular way, but it also allows us to critique the dominant view of information systems, arguing instead that information systems can and should also be conceptualized as flow of decisions that are set in an organizational context.

There are publications in a more general category. Baskarada and Koronios (2013) introduce quality into the discussion, not as a separate entity unto itself, but rather in the context of the quality of data, quality of information, quality of knowledge, and quality of wisdom. They set the DIKW pyramid within a semiotic analysis. Finally, they do a content analysis of the occurrence of the DIKW terms, and DIKW and quality terms, within online news articles. One conclusion they reach is (18): "The paper … [provides] further evidence for the lack of consistency in how the relevant terms are used in every-day language as well as by information systems experts."

Finally, there are publications which take DIKW into other cultures. Mercier, Stevens and Toia (2012) interface DIKW with the New Zealand Mäori culture.

5.0 Drawing it all together.

5.1 The logico-conceptual point of view

From a logico-conceptual point of view, DIKW seems not to work.

5.1.1 Data to information

Ackoff (1989) urges us to gather data with measuring instruments and sensors. But instruments are constructed in the light of theories, and theories are essential to inform us of what the surface indications of the instruments are telling us about a reality beyond the instruments themselves (Bogen 2013). A datum is a proposition like "the voltage in the circuit is 2 volts" it is not an item like "the needle on the voltmeter points to 2" and getting from one to the other requires theories. Data is "theory-laden" (Tuomi 1999).

Data itself can be more than the mere "observable," and it can be more than the pronouncements of "instruments." There are contexts, conventions, and pragmatics at work. In particular circumstances, researchers might regard some recordings as data that report matters that are neither observable nor determinable by instrument (Nielsen and Hjørland 2014).

All data is information. However, there is information that is not data. Information can range much more widely than data; it can be much more extensive than the given. For example, consider the universal statement "all rattlesnakes are dangerous." This statement presumably is, or might be, information, yet it cannot be inferred from data. The problem is with the universality, with the "all." Any data, or conjunctions of data, are singular. For example, "rattlesnake A is dangerous," "rattlesnake B is dangerous," "rattlesnake C is dangerous," etc. are singular in form. Trying to make the inference from "some" to "all' is an inductive inference, and inductive inferences are invalid. The point can be made solely in terms of logic. Data typically is expressed by existential-conjunctive logic, information requires the full first order logic; the latter cannot even be expressed in its entirety by the former; and, in particular, some statements in the latter amount to information and they cannot be inferred from the former (Frické 2009).

Another argument that can be used against a proposed data-to-information step uses the observable-theoretical distinction. Within scientific and other theories there are often terms that are "observable" and other terms which are "theoretical" (Carnap 1956). Observable terms refer to observable properties such as blue, warm, and contiguous with. Theoretical terms refer to theoretical entities (i.e., non-observable entities): for example, electrons, neutrons, and genes. In Ackoff's view, data in the DIKW pyramid concerns observable properties, but in the world of science, there is some information that concerns theoretical terms or theoretical properties. For example, the mass of an electron is $9.10938356 \times 10^{-31}$ kilograms. This statement of mass is information, but it is not data, or a datum, because it does not relate to observable properties. Therefore, there is at least some information that has not come from data as observational units.

5.1.2 Information to knowledge

The step from information to knowledge is also not the easiest. If knowledge is construed as "know-that," then, under some views of information and knowledge, information and knowledge are much the same. In which case, moving from information to knowledge might not be so hard. However, in the context of DIKW, knowledge is usually taken to be "know-how," and that makes the step difficult. Consider a young person learning how to ride a bike. What information in particular is required? It is hard to say, and maybe no information in particular is required. However, like many skills, riding a bike is definitely coachable, and information can improve performance. For example, the information that a bike rider's having the weight on the outside pedal and the inside handle bar end is pretty well optimal for cornering, or the information that a bike rider lowering body position and reducing frontal area reduces aerodynamic drag, can improve bike riding skill. Know-how can benefit from information. The problem is in the details. All know-thats are propositional in form and, given a suitable expressing language, they can be written down and recorded or stored in data-bases. Know-hows are different. Some know-hows might be articulated as procedural rules, usually "if-then" rules. Knowing how to solve a quadratic equation, how to bid at Contract Bridge, and similar, might be conceived like this. Such rules, of course, can be written down and stored in a repository. Other know-hows do not seem to be of this kind. Knowing how to ride a bicycle is not plausibly a matter of the brain scanning, and selecting among rules like "if you want to turn left, lean left." So, much of know-how cannot really be explicitly recorded. Within cognitive science, there is the different distinction between "procedural" and "declarative" knowledge (Anderson 1976; Newell 1972). Declarative knowledge amounts to the know-thats of philosophy. But procedural knowledge is inexpressible. So, someone might learn to ride of bicycle from a book by following declarative knowledge rules like "if you want to turn left, lean left" then, when the rider masters the skill, that declarative knowledge dissolves into the inherently inexpressible procedural knowledge know-how skill of knowing how to ride a bike. As mentioned, another distinction of relevance in this context is Polanyi's (1958) distinction between tacit and explicit knowledge. Tacit knowledge is the inexpressible personal how-to knowledge of domain experts; explicit knowledge is the expressible and recordable know-that knowledge that, for instance, fills books and libraries. Much of "know-how" and procedural knowledge is tacit. In sum, know-how can involve tacit knowledge, and it may or may not be intellectualist (i.e., re-framable in terms of know-thats). The details of the relationship between information and know-how are unclear.

5.1.3 Knowledge to wisdom

Wisdom is in an entirely different category to data, information, and know-how. Wisdom certainly uses or needs data, information and know-how, but it uses and needs more besides. Wisdom is not a distillation of data, information, and know-how. Wisdom does not belong at the top of a DIKW pyramid. Basically, this is acknowledged implicitly by all writers on the topic, from Plato, through Ackoff, to modern researchers.

5.2 DIKW in the setting of work processes

So much for DIKW considered logico-conceptually, what about DIKW in the setting of work processes? Frické (2009) argues that the DIKW theory seems to encourage uninspired methodology. The DIKW view is that data, existing data that has been collected, is promoted to information and that information answers questions. This encourages the mindless and meaningless collection of data in the hope that one day it will ascend to information—i.e., pre-emptive acquisition. It also leads to the desire for "data warehouses," with contents that are to be analyzed by "data mining." Collecting data also is very much in harmony with the modern "big data" approach to solving problems. Big data, and data mining are somewhat controversial (Austin and Goldwasser 2008; Austin et al. 2006; Dye 2007; Frické 2015). The worry is that collecting data "blind" is suspect methodologically. An analogue of an information scientist collecting data is a scientist collecting observations. Popper (1963, 46) writes about that:

> The belief that we can start with pure observations alone, without anything in the nature of a theory, is absurd; as may be illustrated by the story of the man who dedicated his life to natural science, wrote down everything he could observe, and bequeathed his priceless collection of observations to the Royal Society to be used as inductive evidence. This story should show us that though beetles may profitably be collected, observations may not.

Also, analyzing "raw" data—data without background theory—can lead to all sorts of unsound statistical manipulations (Bretz and Hsu 2007; Cohen 1994; Frické 2015; Huff 1954; Johansson 2011; Meehl 1978; Mills 1993). A manager of information does not want to be collecting data hoping that it might be promoted to information. A better methodology is more top-down and just-in-time. A good theory of questions may delimit exactly the information needed to answer a particular question; and then the raising of a question will itself direct the search for information, observations, or data.

As mentioned, know-how can be improved by information. But the situation here is again that of requiring top-down background knowledge or theorizing. A manager will often have a template of the know-how; the manager will know most everything except for some parameters or particular details. Information might give those details. To revisit an earlier quotation, Ackoff asserts (1989, 4): "Knowledge is know-how, for example, how a system works. It is what makes possible the transformation of information into instructions. It makes control of a system possible."

If know-how is going to become instructions, it should not be the ineffable procedural knowledge of cognitive science, nor should it be philosophy's inarticulable know-how of mundane skills (like bike riding). It should not be tacit. What Ackoff attempts is not the best way to approach what he is aiming for. What is best, is to take knowledge to be know-that. Then some of those explicit know-thats will be rules or instructions (like "if the thermostat is set lower, the room will become cooler"). All of these can be recorded and stored and thus have a role central to the province of "information management, information systems and knowledge management literatures."

Know-how in management is simply more involved than DIKW depicts it. As Weinberger (2010) writes:

> Knowledge is not a result merely of filtering or algorithms. It results from a far more complex process that is social, goal-driven, contextual, and culturally-bound. We get to knowledge — especially "actionable" knowledge — by having desires and curiosity, through plotting and play, by being wrong more of-

> ten than right, by talking with others and forming social bonds, by applying methods and then backing away from them, by calculation and serendipity, by rationality and intuition, by institutional processes and social roles. Most important in this regard, where the decisions are tough and knowledge is hard to come by, knowledge is not determined by information, for it is the knowing process that first decides which information is relevant, and how it is to be used.

Wisdom is important in management and decision making, and there is a literature on this (see, for example, Sternberg 2017). But, seemingly, no one wants to relate wisdom in management to the DIKW pyramid.

5.2.1 Summing up

In sum, DIKW does not sit well in modern business process theory. To quote Weinberger (2010) again:

> The real problem with the DIKW pyramid is that it's a pyramid. The image that knowledge (much less wisdom) results from applying finer-grained filters at each level, paints the wrong picture. That view is natural to the Information Age which has been all about filtering noise, reducing the flow to what is clean, clear and manageable. Knowledge is more creative, messier, harder won, and far more discontinuous.

6.0 Conclusion

What are the general implications of this analysis of the DIKW-pyramid for knowledge organization?

If the DIKW model were adequate, knowledge organization could be understood as a purely inductive process based on data as units. Because of issues such as the theory-laden nature of perception, there is, however, a two-way interactive process between data and knowledge: knowledge influences what is considered data and data take part in building knowledge. Knowledge organization is therefore not just based on empiricism and induction, which may be considered unfruitful philosophical positions. Data may be understood as what is or can be represented in databases[6]. Contrary to the empiricist/inductivist philosophy behind the DIKW-model the pragmatic semiotics of Charles Sanders Peirce, and the concept of sign[7] is based on an advanced understanding on how objects in the world, their symbols, and their interpretations are interrelated. From this perspective, the DIKW-model seems naïve and problematic. This demonstrates—again—that theoretical issues in knowledge organization are intimately connected with epistemological theories.

Notes

1. Hopefully, this encyclopedia (IEKO) will also at a later point have independent articles about each of these concepts.
2. 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 information?
   Eliot (1934, 7, "Choruses," Chorus 1)
3. Jennex and Bartczak (2013) suggests that the reverse is the case: there is more information than data, more knowledge than information, and more wisdom than knowledge.
4. In particular, the physical transmission of encoded information, its compression and error correction via Huffman trees, Hamming codes and the like, have their theoretical foundation with Shannon (Pierce 1980).
5. For example, Svenonius (2000) uses "information organization" for what is commonly termed "knowledge organization."
6. Databases as well as their individual records may be understood as kinds of documents. In the case of bibliographical databases, they represent metadata or metadocuments about other documents.
7. "A sign, or representamen, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the interpretant of the first sign. The sign stands for something, its object. It stands for that object not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of the representamen" (Peirce 1960, CP 2.228 emphasis original).

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