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The wisdom hierarchy: representations of the DIKW hierarchy

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Abstract.

This paper revisits the data–information–knowledge–wisdom (DIKW) hierarchy by examining the articulation of the hierarchy in a number of widely read textbooks, and analysing their statements about the nature of data, information, knowledge, and wisdom. 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 literatures, but there has been limited direct discussion of the hierarchy. After revisiting Ackoff's original articulation of the hierarchy, definitions of data, information, knowledge and wisdom as articulated in recent textbooks in information systems and knowledge management are reviewed and assessed, in pursuit of a consensus on definitions and transformation processes. This process brings to the surface the extent of agreement and dissent in relation to these definitions, and provides a basis for a discussion as to whether these articulations present an adequate distinction between data, information, and knowledge. Typically information is defined in terms of data, knowledge in terms of information, and wisdom in terms of knowledge, but there is less consensus in the description of the processes that transform elements lower in the hierarchy into those above them, leading to a lack of definitional clarity. In addition, there is limited reference to wisdom in these texts.

Keywords: DIKW hierarchy; wisdom hierarchy; wisdom; knowledge management; wisdom management

1. Introduction

The data–information–knowledge–wisdom hierarchy (DIKW), 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 knowl-

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edge literatures. It is often quoted, or used implicitly in definitions of data, information and knowledge in textbooks in information management, information systems and knowledge management. The hierarchy is used to contextualize data, information, knowledge, and sometimes wisdom, with respect to one another and to identify and describe the processes involved in the transformation of an entity at a lower level in the hierarchy (e.g. data) to an entity at a higher level in the hierarchy (e.g. information). The implicit assumption is that data can be used to create information; information can be used to create knowledge, and knowledge can be used to create wisdom. As Ackoff [1], whose paper is often cited when the DIKW hierarchy is quoted, explains, each of the higher types in the hierarchy 'includes the categories that fall below it' (p.3).

The definitional role of the DIKW hierarchy positions it as a central model of information management, information systems and knowledge management. Yet, whilst there has over the years been significant debate about related issues such as the nature and definition of information, both before and since Ackoff's paper, e.g. [2–11], and more recently considerable focus on the definition of knowledge, e.g. [12–20], there has been:

- little direct discussion of the DIKW hierarchy itself, its meaning and contribution; and
- limited discussion of the nature of wisdom, and even less discussion of the organizational processes that contribute to the cultivation of wisdom.

The objective of this paper then is to revisit the DIKW hierarchy, by examining the articulation of the hierarchy in a number of widely read textbooks, and to analyse their statements about the nature of data, information, knowledge, and wisdom. This paper is a theoretical paper designed to open debate, promote reflection, and lift the discussion to wisdom from where it is languishing currently at the level of knowledge. An improved appreciation of the relationships between knowledge and wisdom, as well as the 'foundational concepts' of data and information, may provide a context for achieving more convincing success in knowledge management, and more importantly organizational achievement. This paper does not seek to make a broader theoretical contribution to the philosophical debates about the nature of information or knowledge advanced variously in the literatures of information philosophy and knowledge management. Rather its focus is on popular articulations of the hierarchy to which students and professionals are exposed. Shenton [21] suggests that the research subject's and the professional's notion of 'information' are a critical factor in the study of information behaviour. The pragmatic approach adopted in this article therefore has equal, although different, relevance for information practice and research as do the more numerous philosophical debates.

The preoccupation with information and knowledge has led to the DIKW hierarchy being called respectively the information hierarchy or the knowledge hierarchy. Here we refer to the DIKW hierarchy as the wisdom hierarchy, for two reasons:

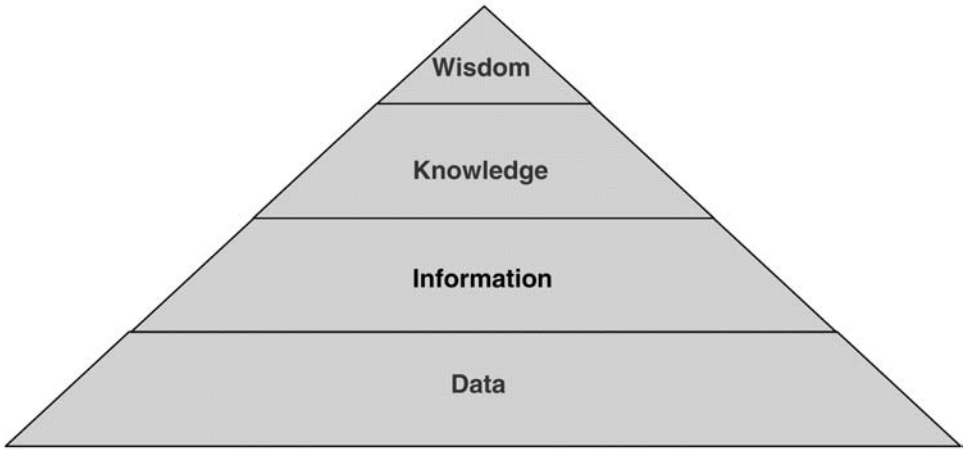

Fig. 1. The DIKW hierarchy.

- Wisdom is identified as the pinnacle of the hierarchy.
- One of our objectives in revisiting the DIKW hierarchy is to further illuminate the notion of 'wisdom'.

This article, then, starts with a section that outlines the wider literature that explores the nature of information and knowledge, and then revisits and summarizes Ackoff's original articulation of the hierarchy. Next, definitions of data, information, knowledge and wisdom as articulated in recent textbooks in information systems and knowledge management are reviewed and assessed, in pursuit of a consensus on definitions and transformation processes. This process brings to the surface the extent of agreement and dissent in relation to these definitions, and provides a basis for a discussion as to whether these articulations present an adequate distinction between data, information and knowledge. In addition, there is limited reference to wisdom in these texts. The article concludes with suggestions for further theoretical development.

2. Theoretical context

The original formulation of the DIKW hierarchy will have been informed by theoretical discussion on the nature of information and knowledge. Whilst the purpose of this paper is to present an analysis based on 'popular' articulation and definitions of data, information, knowledge and wisdom, and the relationships between these, it is useful to outline briefly the range of the theoretical debates that underlie and inform these more popular representations. The theoretical and philosophical discussion has two major branches: information philosophy, focusing on the nature of information; and knowledge management, which contributes to notions of knowledge. Whilst these fields are distinct they do share some common foundations, and since some authors argue either that information and knowledge are the same thing, or that they are used interchangeably [22–24], it may be difficult to justify any discussion of information that does not also explore knowledge and vice versa. Choo suggests that 'the knowing organisation represents an information-based view of organisations' [25, p. 1].

The essential nature of information, since it is fundamental to our existence, has been considered by many disciplines, including communications theory, library and information science, information systems, cognitive science, and organization science [5]. This has generated multiple perspectives on the nature of information. Floridi suggests that 'Of our mundane and technical concepts information is currently one of the most important, most widely used and least understood.' [6, p. 459] He identifies six approaches to the definition of information, respectively: the communication theory approach, the probabilistic approach, the modal approach, the systemic approach, the inferential approach, and the semantic approach. Recently, there has been a renewed interest in this area arising out of the formulation of the new discipline of the philosophy of information [6–10]. Information philosophy focuses on 'the critical investigation of the conceptual nature and basic principles of information, including its dynamic (especially computation and information flow)' [7, p. 555]. Contributors to this debate agree that the word information has been given different meaning by different writers, and that consensus on the meaning of the word 'information' has not been achieved [26].

Debates about the nature of knowledge are equally longstanding, and have also gathered momentum in recent years with the blossoming of the discipline of knowledge management. Plato [27] first defined knowledge as 'justified true belief' and this concept has been debated over the centuries by Aristotle [28], Descartes [29], Kant [30], Polanyi [31] and others. Kakabadse et al. [19], drawing on these debates, suggest that knowledge 'can be conceived as information put to productive use'. Knowledge management, like information philosophy, has been influenced by a variety of disciplines, including: philosophy, cognitive science, social science, management science, information science, knowledge engineering, artificial intelligence, and economics. Kakabadse et al. [19] propose five different knowledge management perspectives each of which takes a different stance on the nature of knowledge and knowledge processes: philosophy-based, cognitive, network, community, and quantum.

To conclude and lead into our more specific exploration of the literature on the DIKW hierarchy, both the information philosophy and knowledge management literatures are longstanding, and offer multiple perspectives on the definition of information and knowledge. Some contributions also

explore the nature of data and wisdom, but much of the discussion is focused on one of the elements in the DIKW hierarchy rather than on all of the elements, and the relationship between them.

3. The origins of the wisdom hierarchy

Many authors agree that the first appearance of the hierarchy was in T.S. Eliot's poem *The Rock* in 1934 [32]. This poem contains the following lines:

> Where is the wisdom that we have lost in knowledge?
>
> Where is the knowledge that we have lost in information?

In more recent literature, authors often cite Ackoff's 1989 paper as a source for the hierarchy. Ackoff's article, entitled *From data to wisdom*, proposed a hierarchy with the following levels: data, information, knowledge, understanding and wisdom. Ackoff included understanding in his hierarchy, but more recent commentators have disputed that understanding is a separate level.

Ackoff defines data, information, knowledge, understanding, intelligence and wisdom and explores the processes associated with the transformation between these elements. Most of these definitions and processes are described from an information systems perspective, despite Ackoff's initial description of the types in the hierarchy as content of the human mind.

> 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 – for example, there can be no wisdom without understanding and no understanding without knowledge [1, p. 3].

Ackoff offers the following definitions of data, information, knowledge and wisdom, and their associated transformation processes:

- Data are defined as symbols that represent properties of objects, events and their environment. They are the products of *observation*. But are of no use until they are in a useable (i.e. relevant) form. The difference between data and information is functional, not structural.
- Information is contained in descriptions, answers to questions that begin with such words as who, what, when and how many. Information systems generate, store, retrieve and process data. Information is inferred from data.
- Knowledge is know-how, and is what makes possible the transformation of information into instructions. Knowledge can be obtained either by transmission from another who has it, by instruction, or by extracting it from experience.
- Intelligence is the ability to increase efficiency.
- Wisdom is the ability to increase effectiveness. Wisdom adds value, which requires the mental function that we call judgement. The ethical and aesthetic values that this implies are inherent to the actor and are unique and personal.

Ackoff's article is not the only early mention of the hierarchy. Cleveland [33] makes an early mention of the hierarchy which is to be found in the information science literature. At around the same time as Ackoff, Zeleny [34] also discusses the DIKW hierarchy, and proposes an additional level, enlightenment, at the top of the hierarchy. Zeleny's model is compared with Ackoff's in Table 1. Enlightenment is not only answering or understanding why (which he defines as wisdom), but going further and attaining the sense of truth, the sense of right and wrong, and having it socially accepted, respected and sanctioned. Also Cooley [35] builds the DIKW hierarchy during his discussion of tacit knowledge and common sense.

More recently, Bellinger et al. [36] have elaborated further on Ackoff's exposition, suggesting that understanding is not a separate level, but rather that understanding supports the transition from each stage to the next. They suggest that moving from data to information involves 'understanding relations', moving from information to knowledge involves 'understanding patterns', and moving

Table 1
Comparing Ackoff's and Zeleny's definitions of data, information, knowledge and wisdom

	Zeleny [34]	Ackoff [1]
Data	Know nothing	Symbols
Information	Know what	Data that are processed to be useful; provides answers to who, what, where and when questions
Knowledge	Know how	Application of data and information; answers how questions
Understanding		Appreciation of why
Wisdom	Know why	Evaluated understanding
Enlightenment	Attaining the sense of truth, the sense of right and wrong, and having it socially accepted, respected and sanctioned	

from knowledge to wisdom involves 'understanding principles'. The label 'DIKW hierarchy', and the omission of understanding as a separate level in re-iterations of the hierarchy in other sources suggest that there is something of a consensus and that Bellinger et al. [36] are articulating a shared view that understanding should not be considered as a separate level.

Amongst the recent information systems and knowledge management texts analysed below only four actually draw the hierarchy. Chaffey and Wood [37] show the hierarchy in Figure 2, with the additional axes of meaning and value. Pearlson and Saunders [38] suggest that human input goes up in the higher levels of the hierarchy, whilst computer input goes down. Jashapara [39] shows a hierarchy with the levels: data, information, knowledge, wisdom and truth. Choo [25] draws a rather different diagram focusing on the transformation processes between signals, data, information and knowledge.

Typically all of these formulations of the hierarchy share a common view that:

- the key elements are data, information, knowledge, and wisdom;
- these key elements are virtually always arranged in the same order, although some models offer additional stages, such as understanding, or enlightenment;

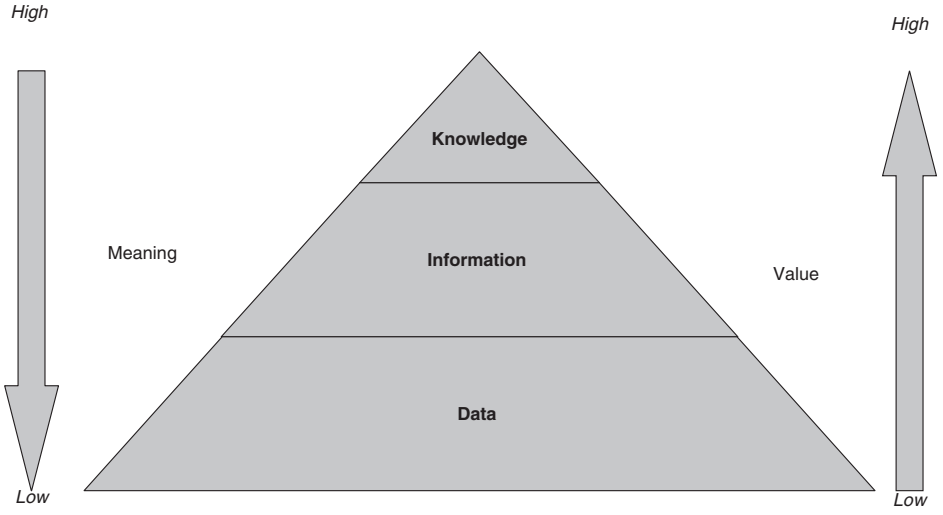

Fig. 2. Data, information and knowledge, according to Chaffey and Wood [37].

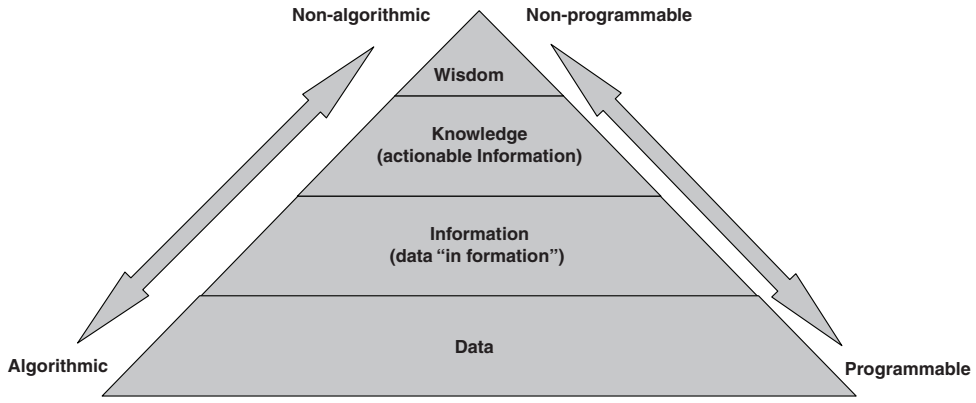

Fig. 3. Data, information and knowledge, according to Awad and Ghaziri [20].

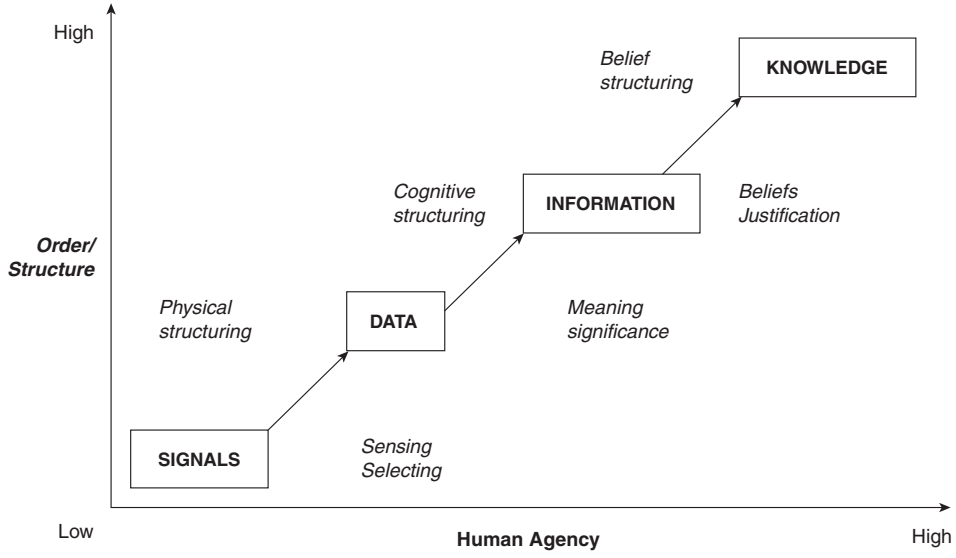

Fig. 4. Data, information and knowledge, according to Choo [25].

- the higher elements in the hierarchy can be explained in terms of the lower elements by identifying an appropriate transformation process; and
- the implicit challenge is to understand and explain how data is transformed into information, information is transformed into knowledge, and knowledge is transformed into wisdom.

4. Aims and methodology

This research does not seek to review all writing that presents definitional debates in relation to data, information, knowledge and wisdom. Rather we examine the popular explicit or implicit articulations of the wisdom hierarchy in a number of recent textbooks in those disciplines at the core of the knowledge revolution, information systems and knowledge management. This analysis is intended to ascertain how some of the key authors of recent books that are read by students and others define the terms, and to investigate:

- which items in the hierarchy are typically defined by writers of textbooks in information systems and knowledge management;
- the extent of any consensus on the definition of data, information, knowledge and wisdom;
- the essential nature of these elements, as defined and described in these sources; and
- the transformation processes associated with moving between levels in the hierarchy.

The textbooks were chosen using the following criteria:

- Recently published, preferably published in 2003 or later. This criterion was important to ensure that all the books were written at a similar time, and had the opportunity to be influenced by current theoretical debates, particularly in the area of knowledge management.
- Published by a major publisher, and therefore having the potential to be widely read, and influential.
- Where possible, books in their second or subsequent edition were chosen, to ensure the selection of books that were established as authoritative. This criterion proved more difficult to apply to knowledge management books, since some of the most useful texts in this area have only been published in their first edition quite recently.
- Availability and convenience.
- Textbooks were preferred to readers or collections of articles because these books were less likely to offer any definition, and when they did those definitions might not be consistent with one another; this made for more difficult analysis and might have unbalanced the perspectives in favour of these sources offering multiple perspectives.

The books in information systems and those in knowledge management were analysed separately in order to investigate any differences in definitions or emphases rooted possibly in their different disciplinary perspectives. Textbooks included in the analysis were [20, 25, 37–50].

The textbooks were analysed through the use of their index and scanned for key phrases that characterized their definition of data, information, knowledge and wisdom. In some instances, these texts offer succinct and straightforward definitions, perhaps with examples. In others a rather more sophisticated exposition is offered which embraces concepts from semiotics, pragmatics and semantics, e.g. [47]. In some texts the definitions are clearly labelled as such, whereas in others the definitions which form the core basis of the comments in the next section have been extracted to capture 'the flavour' of the definition articulated by the author. Typically, definitions of knowledge tend to be more elaborate and discursive than those of data and information.

5. Findings

This section first notes the extent of definition of data, information, knowledge and wisdom in the textbooks that were studied. It then proceeds to summarize and discuss, in turn, the definitions of data, information, knowledge and wisdom offered in this literature.

5.1. Which items are discussed?

Table 2 summarizes the extent of mention of the elements in the wisdom hierarchy. Most books offer a description of data, information and knowledge that can be regarded as a definition. Two of the knowledge management textbooks did not define data or information, but did offer a definition of knowledge. Such books may take the definition of data and information as a given, even though they define knowledge in relation to information. One of the information systems textbooks did not define knowledge. In general then most books recognized the importance of defining all three concepts, whether their primary focus was on 'information' within information systems, or 'knowledge' as in knowledge management. However, concepts above knowledge in the wisdom hierarchy

[20] E.M Awad and H.M. Ghaziri, *Knowledge Management* (Pearson Education International, Upper Saddle River, NJ, 2004).
[25] C.W. Choo, *The Knowing Organization: how Organizations use Information to Construct Meaning, Create Knowledge, and make Decisions* (OUP, Oxford, 2006).
[37] D. Chaffey and S. Wood, *Business Information Management: Improving Performance using Information Systems* (FT Prentice Hall, Harlow, 2005).
[38] K.E. Pearlson and C.S Saunders, *Managing and using Information Systems: a Strategic Approach* (Wiley, New York, 2004).
[39] A. Jashapara, *Knowledge Management: an Integrated Approach* (FT Prentice Hall, Harlow, 2005).
[40] L.M. Jessup and J.S. Valacich, *Information Systems Today* (Prentice Hall, Upper Saddle River, N J, 2003).
[41] P. Bocij, D. Chaffey, A. Greasley, and S. Hickie, *Business Information Systems: Technology, Development and Management for the e-Business* 2nd edn (FT Prentice Hall, Harlow, 2003).
[42] T.R. Groff and T.P. Jones, *Introduction to Knowledge Management: KM in Business* (Butterworth Heinemann, Amsterdam, 2003).
[43] K.C. Laudon and J.P. Laudon, *Management Information Systems: Managing the Digital Firm* 9th edn. (Pearson Prentice Hall, Upper Saddle River, NJ, 2006).
[44] E. Turban, R.K. Rainer, and R.E. Potter, *Introduction to Information Technology*, 3rd edn (New York, Wiley, 2005).
[45] D. Boddy, A. Boonstra, and G. Kennedy, *Managing Information Systems: an Organizational Perspective*, 2nd edn (FT Prentice Hall, Harlow, 2005).
[46] G. Curtis and D. Cobham *Business Information Systems: Analysis, Design and Practice*, 5th edn (FT Prentice Hall, Harlow, 2005).
[47] P. Beynon-Davies, *Information Systems: an Introduction to Informatics in Organizations* (Palgrave, Basingstoke, 2002).
[48] S. Newell, M. Robertson, H. Scarbrough, and J. Swan, *Managing Knowledge Work* (Palgrave Macmillan, Basingstoke, 2002).
[49] S. Barnes, *Knowledge Management Systems: Theory and Practice* (Thomson Learning, London, 2002).
[50] C. Depres and D. Chauvel, *Knowledge Horizons* (Butterworth Heinemann, Boston, 2000).

Fig. 5. Textbooks included in the analysis.

received very little attention. Wisdom was only defined by three books, and other higher levels were mentioned by two authors.

5.2. Defining data

Where definitions of data are offered these are typically clearly and succinctly stated, sometimes with examples. In summary the definitions variously suggest that:

- Data has no meaning or value because it is without context and interpretation [27, 40–42].
- Data are discrete, objective facts or observations, which are unorganized and unprocessed, and do not convey any specific meaning [20, 37, 38, 41].
- Data items are an elementary and recorded description of things, events, activities and transactions [43–45].

Choo [25] suggests that data are often elements of larger physical systems (such as books, or instrument panels) which give clues about what data to notice and how they should be read.

Table 2
Extent of definition of data, information, knowledge and wisdom

	Data	Information	Knowledge	Wisdom	Other (e.g. Truth)
Information systems textbooks ($n = 8$)	8	8	7	1	0
Knowledge management textbooks ($n = 7$)	5	5	6	2	2
Total ($n = 15$)	13	13	13	3	2

Jashapara [39] and Choo [25] also introduce the concept of signals. Jashapara [39] suggests that we acquire data from the external world through our senses and try to make sense of these signals through our experience. Choo [25] develops this further and specifically identifies signals as the origin of data, and proposes the processes of sensing and selecting, together described as physical structuring, as transforming signals into data.

Interestingly, these definitions are largely in terms of what data lacks; data lacks meaning or value, is unorganized and unprocessed. They lay the foundations for defining information in terms of data.

5.3. Defining information

Information systems books tend to focus on the relationship between data and information, often defining information in terms of data. The concepts of format, structure, organization, meaning and value feature in the various definitions:

- 'Information is formatted data […(and)] can be defined as a representation of reality' [40, p. 7].
- 'Information is data which adds value to the understanding of a subject' [37, p. 223 based on the European Framework for Knowledge Management].
- 'Information is data that have been shaped into a form that is meaningful and useful to human beings' [43, p. 13].
- 'Information is data that have been organized so that they have meaning and value to the recipient' [44, 45].
- 'Information is data processed for a purpose' [46, p. 3].

Bocij et al. [41] concur with the findings that there are a number of definitions of information in common use, which they suggest are:

- data that have been processed so that they are meaningful;
- data that have been processed for a purpose; and
- data that have been interpreted and understood by the recipient.

Bocij et al. [41] and Curtis and Cobham [46] identify the processes associated with converting data into information. They agree that these are: classification, rearranging/sorting, aggregating, performing calculations, and selection. They do not discuss whether these processes are performed by information systems, or people, or both.

Pearlson and Saunders [38] suggest that such processing of data requires a decision about the type of analysis, and this, in turn, requires an interpretation of the content of the data. To be relevant and have a purpose, information must be considered within the context where it is received and used. Boddy et al. [45] point out that the notion of meaning is subjective, and that what one person sees as valuable information another may see as data with no particular significance. Beynon-Davies [47], recognizing that the meaning of information is both critical and open to many interpretations, embarks on an explanation based on semiotics or semiology. He argues that information can be seen as embodied in signs, and discusses how the elements of semiotics, pragmatics, semantics, syntactics and empirics inform thinking about communication and information.

Five of the knowledge management textbooks also define information, and these definitions also define information in relation to data. For example:

- 'Information is data that have been given meaning by way of context' [42, p. 2].
- 'Information is an aggregation of data that makes decision making easier' [20, p. 36].
- 'Information is data that is endowed with meaning, relevance and purpose' [39, p. 14].

Jashapara also agrees with Boddy et al. [45] that the human receiver determines whether a message is data or information:

> It is the receiver of the data that determines whether a message is data or information [...] Meaning in data often occurs through some form of association with experience or relationships with other data [39, p. 16].

Choo [25] calls this process, which assigns meaning and significance to the perceived facts and messages, 'cognitive structuring'.

To conclude, in both the information systems textbooks and the knowledge management literature, information is defined in terms of data, and is seen to be organized or structured data. This processing lends the data relevance for a specific purpose or context, and thereby makes it meaningful, valuable, useful and relevant.

5.4. Defining knowledge

Definitional statements on knowledge are often much more complex than those for data or information. Indeed a number of the knowledge management texts offer extended definitional discussions on the nature of knowledge, its various representations and manifestations, and philosophical debates on the nature of knowledge. These debates make it more difficult to distil the essence of the statements on the nature of knowledge than it is to capture and represent the definitional statements that relate to data and information. Indeed, as some texts opine:

- 'Knowledge is an intrinsically ambiguous and equivocal term' [49, p. 3].
- 'There is still no consensus on the nature of knowledge, except that it is based on perception that can provide a rational justification for it' [39, pp. 16–17].

Six of the information systems books offer definitional statements in relation to knowledge, frequently defining knowledge in terms of data and information. For example:

- 'Knowledge is the combination of data and information, to which is added expert opinion, skills, and experience, to result in a valuable asset which can be used to aid decision making' [37, p. 223, quoting the European Framework for Knowledge Management].
- 'Knowledge is data and/or information that have been organized and processed to convey understanding, experience, accumulated learning, and expertise as they apply to a current problem or activity' [44, p. 38].
- 'Knowledge builds on information that is extracted from data [...] While data is a property of things, knowledge is a property of people that predisposes them to act in a particular way' [45, p. 9].

Pearlson and Saunders concur that knowledge is information from the human mind and includes reflection, synthesis, and context:

> Knowledge consists of that mix of contextual information, values, experience, and rules [...] Knowledge involves the synthesis of multiple sources of information over time. The amount of human contribution increases along the continuum from data to information to knowledge [38, pp. 13–14].

Bocij et al. [41] differentiate between explicit knowledge and tacit knowledge, suggesting that explicit knowledge can be recorded in information systems, whereas tacit knowledge cannot be recorded since it is part of the human mind.

Some of the knowledge management texts also agree that knowledge is based on information. Barnes [49], for example, suggests that knowledge is information processed in the mind of an individual and that knowledge is justified personal belief that increases an individual's capacity to take effective action. Choo [25] concurs that information becomes knowledge through the process of belief structuring or the formation of justified, true beliefs about the world. Jashapara [39] defines knowledge as 'actionable information', and proposes that actionable information allows us to make better decisions and to provide an effective input to dialogue and creativity in organizations. Awad and Ghaziri [20] suggest that knowledge is human understanding of a specialized field of interest that has been acquired through study and experience, and knowledge may be viewed as an understanding of information based on its perceived importance or relevance to a problem area. Despres and Chauvel

[50] discuss the process associated with the transformation of information into knowledge. To become knowledge, new insights are internalized by establishing links with already existing knowledge, and these links can range from firmly characterized relationships to vague associations. Prior knowledge is used to make sense of received information, and once accepted for inclusion, internalizes the new insights by linking with prior knowledge. Hence, the new knowledge is as much a function of prior knowledge as it is of received inputs. A discontinuity is thus created between the inputs and the resulting new knowledge. The resulting knowledge is formed by combinations of mental objects and links between them and allows us to sense reason, plan, judge, and act.

Other authors also discuss the relationship between knowledge and information in terms of the 'added ingredients':

- 'Knowledge is information combined with understanding and capability; it lives in the minds of people' [43, p. 2].
- 'Embracing a wider sphere than information, knowledge includes perception skills, training, common sense, and experience. It is the sum total of our perceptive processes that helps us to draw meaningful conclusions' [20, p. 37].

Jashapara [39] and Newell et al. [48] mention the importance of the semantic aspects of information in the creation of knowledge. These semantic aspects are founded on our ontological and epistemological assumptions of reality.

Several of the knowledge management texts discuss the difference between explicit and tacit knowledge:

- 'Knowledge exists along a continuum between tacit knowledge (know how) and explicit knowledge (know what)' [39, p. 17].
- 'Tacit knowledge refers to personal knowledge embedded in individual experience and involving intangible factors such as personal belief, perspective, and values [...] Explicit knowledge refers to tacit knowledge that has been documented [...]' [43, p. 3].
- 'Tacit knowledge is knowledge embedded in the human mind through experience and jobs [...] Explicit knowledge is knowledge codified and digitized in books, documents, reports, white papers, spreadsheets, memos, training courses, and the like' [20, p. 47].

In general, they agree that tacit knowledge is embedded in the individual, whilst explicit knowledge is codified and recorded, and as such is designed for sharing.

In summary, there is agreement that knowledge is an elusive concept which is difficult to define. Nevertheless, there are some shared perspectives amongst these authors. Knowledge is typically defined with reference to information, but some discuss the processes that convert information into knowledge, whilst others identify the 'added ingredients'. The processes that convert information into knowledge are variously described as:

- synthesis of multiple sources of information over time;
- belief structuring;
- study and experience;
- organization and processing to convey understanding, experience, accumulated learning and experience; or
- internalization with reference to cognitive frameworks.

The 'added ingredients' definitions suggest variously that knowledge is:

- a mix of contextual information, values, experience, and rules;
- information, expert opinion, skills and experience;
- information combined with understanding and capability; or
- perception, skills, training, common sense, and experience.

Summarizing these definitions, knowledge might be viewed as a mix of information, understanding, capability, experience, skills and values, but it is important to note that not all authors mention all of these elements.

Knowledge management texts are more likely than information systems texts to discuss the difference between explicit and tacit knowledge. In general, they differentiate between tacit knowledge as embedded in the individual and explicit knowledge as residing in documents, databases and other recorded formats.

5.5. Defining wisdom

Arguably the most significant observation is that only three of the books seek to define wisdom, despite its position at the pinnacle of the wisdom hierarchy. Such an omission might lead to a deduction that many authors in information systems and knowledge management view wisdom as being beyond their remit for some reason. It might be argued that they do not see information and knowledge as contributing to wisdom, or indeed of being capable of being interpreted into wisdom. On the other hand, they may agree with Jashapara [39] when he suggests that wisdom is a very elusive concept. It perhaps has more to do with human intuition, understanding, interpretation and actions, than with systems.

The three authors who do mention wisdom recognize the importance of wisdom, and the importance of contextualizing information and knowledge management with reference to wisdom. Jessup and Valacich [40] see wisdom as accumulated knowledge, which allows you to understand how to apply concepts from one domain to new situations or problems. In the knowledge management literature, Awad and Ghaziri suggest that 'Wisdom is the highest level of abstraction, with vision foresight and the ability to see beyond the horizon' [20, p. 40]. Jashapara raises the matter of ethics: 'Wisdom is the ability to act critically or practically in any given situation. It is based on ethical judgement related to an individual's belief system' [39, pp. 17–18].

This relatively limited discussion of the concept of wisdom in these texts is indicative of the limited attention to discussions of the nature of wisdom and how it can be cultivated in the wider information systems, knowledge management and management literatures.

6. Discussion

The analysis of popular articulations of the concepts of data, information, knowledge and wisdom have brought to the surface a number of key issues which have implications for the transparency associated with the widely distributed conceptions of the wisdom hierarchy.

6.1. Relationship between definitions

There is a consensus that data, information and knowledge are to be defined in terms of one another, although data and information can both act as inputs to knowledge. This consensus reaffirms the concept of a hierarchy that links the concepts of data, information and knowledge.

6.2. Transformation processes

There is however less agreement as to the nature of the processes that convert data into information, and information into knowledge, to the extent that it is not clear whether there are in fact three distinct concepts. The tangle of concepts can be explored at two levels – the relationship between data and information, and the relationship between information and knowledge.

There is some agreement that information is seen to be organized or structured data. This processing lends the data relevance for a specific purpose or context, and thereby makes it meaningful, valuable, useful and relevant. In other words structuring data, according to a schema that has meaning and relevance for an individual, community or task, endows meaning, or perhaps the potential for meaning. But it is important to recognize that all data in information systems and in our minds has some structure, as soon as it is collected or deposited. Information systems always code any data element to place it in a database and locate it for subsequent use. People gathering data need to

'make sense' of it to store it relative to other information. So, if structure differentiates data from information, we store information in both our minds and our information systems. On the other hand, whether, for example, an item of data in a database has any meaning for a specific individual, team or organization, depends on the alignment between the data structure and the cognitive schema of the individual, team or organization. Those who argue that information resides in the mind of the recipient are suggesting therefore that meaning, and not structure, is the differentiator between data and information. This would lead to the position that all that can be held in information systems is data. There is no clear consensus on these distinctions.

Now, turning to the distinction between information and knowledge, there would also appear to be some inherent confusion here. Information, it is often suggested, is data processed to be meaningful, and valuable and appropriate for a specific purpose. Yet, knowledge is described as 'actionable information', or information combined with understanding and capability. Yet, surely, since meaning is at the heart of definitions of information, understanding must be necessary to achieve meaning, so it seems difficult to use action ability or understanding as differentiators between information and knowledge. Further, the distinction between explicit knowledge and information is even less defensible. If knowledge is a property of people, and embodies prior understanding, experience and learning [45, pp. 9–10], it is difficult to argue that explicit knowledge, recorded in documents and information systems, is any more or less than information.

6.3. Variables in the wisdom hierarchy

All texts explicitly or implicitly subscribe to the traditional formulation of the hierarchy, although some seek to provide axes that differentiate the different levels of the hierarchy. Interestingly those authors who draw the hierarchy offer a number of different views on the variables that change between the different levels of the hierarchy:

- meaning and value [37];
- human input and computer input [38];
- algorithmicity and programmability [20];
- order, structure and human agency [25].

Yet, none of these mentions concepts such as transferability, actionability or applicability which appear frequently in definitions of information and knowledge. Mapping all of these variables onto the hierarchy would suggest the model in Figure 6. Alternatively, it may be time to consider some alternative interpretations and representations of the wisdom hierarchy, such as:

- Is there a sharp divide between data, information and knowledge, or do they lie on a continuum with different levels of meaning, structure and actionability occurring at different levels? So, for example, it is possible to have knowledge with different levels of meaning and actionability?
- Is it possible to map the wisdom hierarchy onto the levels of information systems, if we believe that information systems have a role at all four levels, as in Figure 7? In this figure the suggestion is not that information systems manage all of information, knowledge and wisdom, but that rather the wisdom hierarchy might be used to map to information systems hierarchies to aid in the definition of the roles of different information systems.
- The wisdom hierarchy suggests that:
  - There is more data than information, than knowledge, than wisdom. Is this desirable and acceptable, or simply a statement of the status quo?
  - The hierarchy with its broad base of data is safe, secure and stable.
  - Wisdom is only attained after much processing of data, information and knowledge, and the process starts with data.

Perhaps the wisdom hierarchy upended as shown in Figure 8 is more evocative. This is a wisdom funnel, where data naturally becomes more concentrated, but the whole edifice is delicately balanced on wisdom and will collapse without sufficient wisdom.

There is very little discussion of the concept of wisdom in the books under analysis, and indeed in the wider information systems, knowledge management and management literature. More work needs to be undertaken to develop an understanding of the applicability and relevance of the concept of wisdom, and of wisdom development and management. In recent years concerns about the limited effectiveness of knowledge management initiatives [51], coupled with the complexity of contemporary management and the complexity and hyper-turbulence of organizational environments, might suggest that organizational theorists need to seek something beyond knowledge [52–55]. Early writings on wisdom often associate two characteristics with wisdom: the use of knowledge and information; and 'right judgement' [56]. Many recent writers develop this notion of wisdom. For example, Meacham, cited in [57], defined wisdom as an attitude towards belief, values, knowledge, information, abilities and skills. He argued that wisdom was not in what was known but rather in the manner in which knowledge was held, and how that knowledge was put to use. Baltes and Kunzmann argue that wisdom is not primarily a cognitive phenomenon, but that it

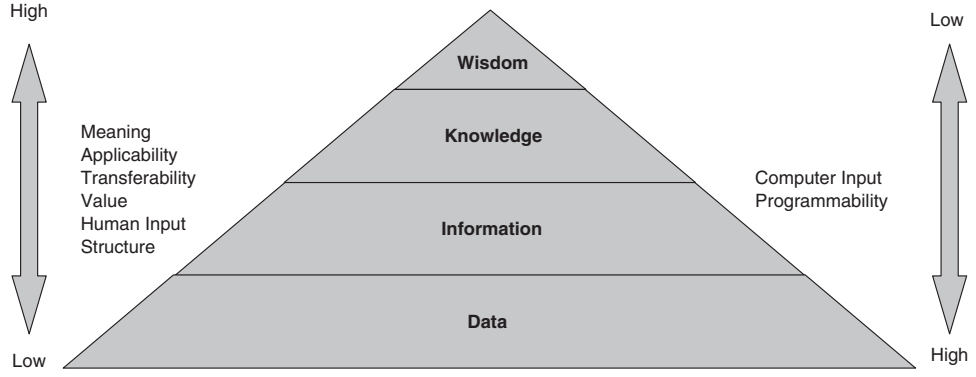

Fig. 6. The wisdom hierarchy.

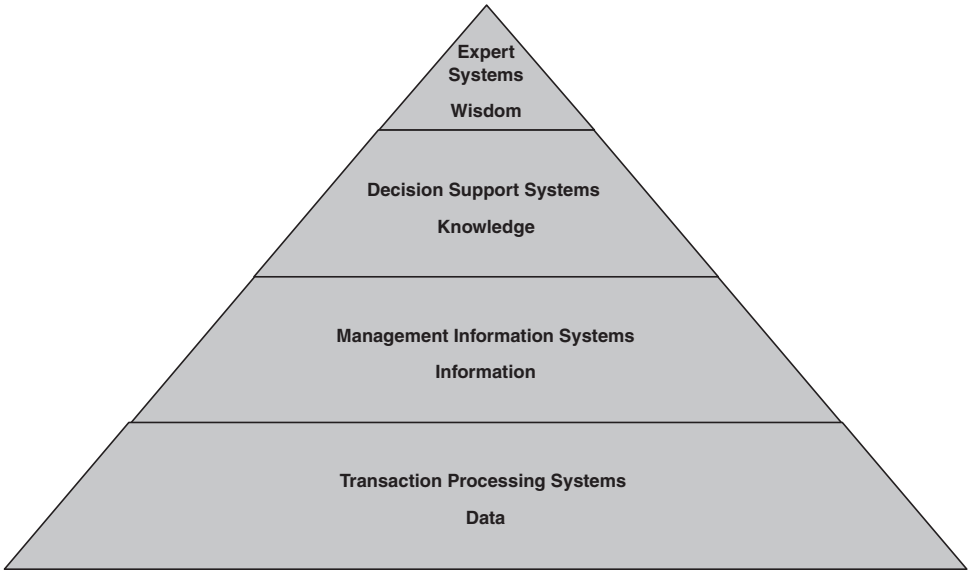

Fig. 7. The wisdom hierarchy mapping to types of information systems.

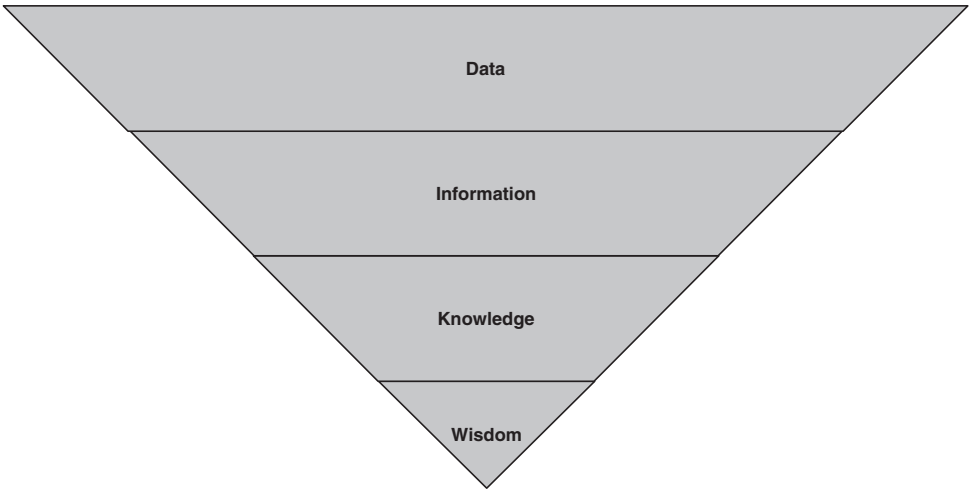

Fig. 8. The wisdom hierarchy upended.

involves cognitive, emotional and motivational characteristics, and define wisdom as 'expert knowledge and judgement about important, difficult and uncertain questions associated with the meaning and conduct of life' [58, p. 131].

Bellinger et al. suggest that, due to the inherent ethical aspect of wisdom, computers do not have and never will 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' [36, p. 2].

Rowley summarizes some of these earlier debates by defining wisdom as:

> The capacity to put into action the most appropriate behaviour, taking into account what is known (knowledge) and what does the most good (ethical and social considerations) [56, p. 257].

The main discussion of wisdom in the management literature is in the context of leadership. Wisdom is seen as a desirable and even essential characteristic of executive business leaders [59, 60]. This has provoked some discussion about approaches to wisdom development, which, in addition to the development of self, involves the development of knowledge, and the development of awareness of the nature of knowledge and knowledge processes [61].

These various theoretical debates on the nature of wisdom all subscribe to the belief that there is a link between knowledge and wisdom.

7. Conclusion

This paper has revisited the DIKW hierarchy, referred to here as the wisdom hierarchy, by examining articulations of the hierarchy in a number of recent textbooks in information systems and knowledge management. Through this process it has sought to assess whether there is a clear consensus on:

- the structure of the hierarchy; and
- the definitions of the elements in the hierarchy.

The hierarchy is only mentioned explicitly in a few books, but it is implicit in the definitions of data, information, knowledge and wisdom across all books. Typically information is defined in terms of data, knowledge in terms of information, and wisdom in terms of knowledge. However, there is less consistency in the description of the processes that transform elements lower in the hierarchy into those above them, and some consequent lack of definitional clarity. In particular, we propose that:

- It is necessary to distinguish between meaning and structure as differentiators between data and information, and this has consequences for whether information is embedded in systems or people's minds, or both.
- The distinction between definitions of information as data processed to be meaningful, valuable and appropriate for a specific purpose, and definitions of knowledge and 'actionable information' overlap and need further investigation.
- If knowledge is a property of the human mind, with the potential for action, explicit knowledge cannot be any more or less than information.

In addition, despite being at the top of the DIKW hierarchy, wisdom is a neglected concept in the knowledge management and information systems literature. If the purpose of information systems and knowledge management initiatives is to provide a basis for appropriate individual and organizational actions and behaviour more researchers and practitioners need to engage with the debate about the nature of individual and organizational wisdom.

This article seeks to provoke and promote debate about the fundamental concepts of the disciplines of information management, information systems and knowledge management. It will have succeeded if it promotes further debate on:

- the meaning and application of the wisdom hierarchy;
- the link between knowledge and wisdom at individual and organizational levels.

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