Hierarchy of Knowledge – from Data to Wisdom

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Abstract :
This paper aims at quantifying data, information, theory, and other factors needed to create a pyramid of knowledge. The only datum, the only one there is, is the amount of data generated or has been generated. To achieve this, we have modified the more common DIKW hierarchy of four levels into an articulation of a six- level framework, data, information, theory, area, type, and wisdom. There is considerable discussion of the nature of theory to illustrate its great breadth across areas of human endeavour. In this model, knowledge is replaced by theory, area, and type, and wisdom is interpreted as a pinnacle of thought. Using a double exponential model, with three parameters, and based on reliable estimates of the amount of extant data, we create a numerical hierarchy and compare it with reasonability. One key point is both hierarchies are not strict, with a lower level subsumed to the next level.

Keywords : *DIKW framework, theory, type, area, data, model, hierarchy, quantification*

INTRODUCTION

The goal is to begin with data, take a few steps, and end up with wisdom. The steps between are usually called the hierarchy of knowledge, upon much has been written. Most prominently is the DIKW pyramid which places wisdom at the top, followed by knowledge, information, and data [1-4]. It is made clear that this is a hierarchy with data accumulating to information, information accumulating to knowledge, and knowledge transformed into wisdom. The definitions of terms vary and so do the transitions. In fact, some information may contribute to multiple forms of knowledge, and so forth. So, while it is a hierarchy in the sense given, it does not strictly follow a tree structure as does a corporate organizational chart. For example, the definition of knowledge, a foundational term in most of philosophy, is and always has been vague [3]. The DIKW pyramid is usually shown as in Fig. 1.

Data are those observed or recorded facts such as Saturday AM, January 7, 1955, snow, temperature 21F, barometric pressure 29.12, location Boston, all at different locations on the tape. Data are usually discrete, objective, and unorganized [5]. They have no independent meaning or value. **Information** is accumulated, assembled, or processed data through processes such as referential, type, purpose, relevance, and interpretation. Example: On Saturday morning January 7, 1955; it snowed in Boston. More primitively, we may experience hearing noises outside. I know of noises such as trucks rumbling, trash cans banging together, thunder, and more. The information statement comes as "I heard thunder." The mind makes a judgment, though it can be wrong. So, information can be derived from putting data together or making simple conclusions from experience. A computer can do this as well in these cases, the point being that computers can and do generate information. This is the essence of the big data movement, the purpose of which is to put data together into actionable assemblies, i.e. information. With so much data generated nowadays, these new tools and data mining have the capacity to form information well beyond the capacity of any brain. A workable definition of knowledge is that 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" [6]. All definitions involve human processing, usually involving these terms and expertise, skill, belief, and expert opinion. For all, there is a general basis upon which to make the conversion. This can be called a theory. Theory discussed in Section 3, allows this assembly, and moreover gives the rules for doing so.

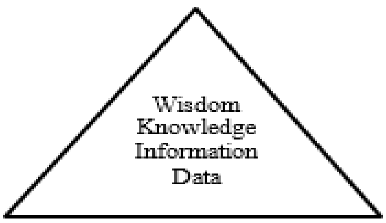

Figure 1. The DIKW Pyramid

To illustrate just one difficulty with considering knowledge as actionable information, we note the statement, "It snowed in Boston." To a resident of Borneo, it may be information, but little more than useless data. To the traveller to Boston, there is an alert (i.e. information) about weather conditions, and therefore becomes knowledge. To the resident of Boston, it is certainly knowledge, but temporal knowledge. Discussing knowledge opens a host of qualifiers, modifiers, and catalysts. Thus, associated with knowledge, factors such as location, time, topic, and relevance have significance [2].

Wisdom, more so than knowledge, is difficult to describe. Wisdom comprises knowledge about knowledge, knowing what knowledge has relevance and what knowledge to apply. Similar to the top levels of Bloom's taxonomy, wisdom seems to imply the ability to create or synthesize, and evaluate [7] using knowledge. Yet, this is also the role of theory, to which attention will be given in the two following sections. The main thrust of this paper is on the quantification of these pyramids. Wisdom is singular in that it is not quantifiable as compared with data, information, and knowledge.

THE DITAT-W HIERARCHY

Assuming the definitions of data and information are clear, the remainder of our terms are more concrete with hopefully less ambiguous meanings. Data is a collection of bits or simple facts, perhaps some streaming content and the like. Information is the collection of data into groups having meaning. The next element in the hierarchy is the **theory**, which accumulates information into a coherent body of information, perhaps called knowledge. In this way, we say a theory is the container of knowledge, information, and data. Theories are generally comprised of hypotheses or principles, propositions, explanations, bound by a logic. It is interesting that depending on the subject matter, the nature of these components, including the logic, may differ widely across theories. If it is desired to associate knowledge with theory, it is then important to accept as many different forms of knowledge as forms of theory. It is the theory that certifies or sanctions what knowledge is. Some theories such as religions allow miracles; some such as mathematics allows only theorems and proofs; others such as business allow laws such as (the unproved but works) Cobb's law of production. Toward quantification, many thousands of official theories and orders more of local specific theories exist.

The transition from information to theory has an intermediate step, called the proto-theory, where the theory is not well established but in a sort of gestation as individuals or groups work to create a coherent theory. It may also involve multiple yet differing proto-theories, each lacking sufficient consensus or evidence for a fully accepted theory. This process may take many decades, such as with plate tectonics. As well, Euclid's geometry no doubt went through a similar period, before the perfected form was published. Records from ancient times do not exist because when a new more authoritative work succeeded another, only it was copied. The next level affirms that theories are separated into respective **areas** such as psychology, business, or mathematics. These can be blended with one area using theories from another as components. Above that, we organize all the areas into **types** such as physical, human, and intellectual areas. The latter of these might include philosophical, religion, and others which actually together with physical theories could be shared with alien civilizations. Only the second, human based, are unique to us.

Also, we could include among the types those of communication, economics, and medicine, bringing a total to six. Arguably, they could be subsumed by the first three. Religious theories may be given their own type, perhaps unique in allowing miracles among their data or information. In most versions of DIKW the fourth level is wisdom, and we might include as area-specific wisdom, as well. In this diagram wisdom, which is a collective, accumulates all areas into an attempt to unify multiple diverse dimensions. Indeed, wisdom has various definitions such as accumulated knowledge applicable across domains or to new situation (8). Also, it could be the highest level of abstraction and vision foresight [9]. In sum, there are six levels in this pyramid – the so-called DITAT-W, or DITAT pyramid for short. See Fig. 2. Let us add that for each theory there is a full DIKW pyramid, with the provision made that external data and information may be co-opted, that both information and knowledge have relevant meanings.

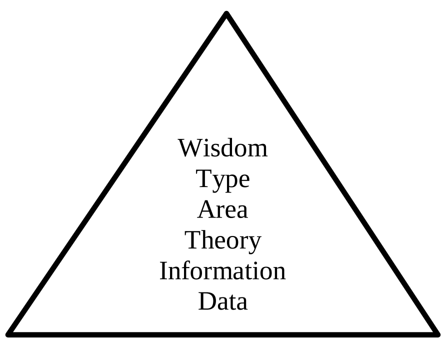

Figure 2. The DITAT-W pyramid

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After a fashion, the top of the pyramid, with wisdom, can be regarded as a placeholder, as wisdom is the vaguest of all the terms. It is there somewhat to create a pinnacle to the model, namely, a single concept at the top. It also refers to an ability to synthesize, coalesce, and evaluate. Wisdom may also be regard as different depending on the theory, area, or type. This would allow wisdom to be as multi-faceted as the other levels. The models considered so far in the literature fail to measure these divisions with a common unit. Foremost, it is rather difficult to measure data in terms of theories or with the DIKW pyramid knowledge. Determining how much data it takes to make a theory is a difficult task, partly because of the wide variation. With the previous settings of this paper, we generally measured numbers of people. Nonetheless, we make an attempt on the basis of pure numbers based on higher order models. It will give some insights into huge relative magnitudes. Most of the conversions from data on up are the results of human thought. It takes a brain to convert data to information, a brain to convert information to a theory, and so on. In areas, it takes different types of brains to decode the data into different forms of information and then to theoretic channels.

Data generated each year is staggering. It is estimated (see Cisco report[10]) each year we generate 10 **zettabytes** of data and it's doubling every year or so. A zettabyte, in magnitude, is a 1 followed by 21 zeros, or 10^{21}. That is a big number. Storing 10 zettabytes of data would require the capacity of a high-end computer for every person on the planet. So, what kind of model can take us from the single unit of wisdom to 10 zettabytes (10^{22}) of data in just six steps?

Both the DIDAT and DIKW hierarchies exhibit a nonstandard and highly nonlinear quality within their genre. The order is not fully inclusive. For example, not all information is every converted to knowledge or to a theory. Some information remains as *orphans* in the progression to wisdom. The same is true for every level transition to the next one up. What is data? Much data is only available as a single entity. The sniff of the lion by the gazelle is data. At one scale, the number dialled, then stored in some file, is data. On another scale, a book could be data if say it was table of logarithms, but more likely forming information, though it could also be a theory. Likewise, a chapter could be the same, but a paragraph is information, and the single word is data.

THE NATURE OF THEORY

A working understanding of theory suffices here. So, the reader interested in quantification aspects may skip to Section 5. Here we offer further explanation of the nature of theory. The purpose is to sketch the detail of the vast array of theory types by their many differing characteristics. In brief, a theory is not a mono-logical construct. It shows how theory is bound up with knowledge, but more the important characteristics of theory often rests with predictability. Currently, the advent of machine learning is involved with the prediction of what was not only unknown but unsuspected [11.12]. This leads one to consider that machines are becoming valuable assistants, or even leaders, in enhancing theories. As well, computers are now able to prove original theorems in mathematics, theorems unproved by humans in many cases [13].

A **theory** is an explanation or prediction based upon hypotheses, supported by evidence, and established by logic. This appears to be easy criteria, but is rather complex. It can and should employ previous explanations or predictions. This is the way to stretch its margins to give it a *higher validity*. The more a theory explains, the stronger it becomes. The what, why, and wherefore, together with the limits, range, and extent, and examining the good, the bad, and the variation should clarify or confuse the notion. It is perhaps the examination of theory extinction and the qualities of bad theories that better define good theories. Theories are containers of facts, knowledge, rules, explanations and predictions. When one theory impinges upon the domain of another or the one upon conclusions of another, there can be conflicts. Many theories are explanations with little or no evidence, with hardly any hypotheses, and with no apparent logic. They just offer an explanation. Such explanations are usually simple to understand, reasonable, sometimes based apparently on an analogy. Even Charles Darwin applied modern events as an analogy for genetic evolution. Such are entirely believable, especially when there is no body of knowledge to review. For example, the greatest physician of antiquity Galen suggested that digested food was transported to the liver where it was transformed into blood. Combine this with the millennia surviving theory of bloodletting [14]). There was no real scientific-like supporting evidence whatsoever. These theories survived for two millennia based only on authority.

On a more modern front, suppose a distinguished physicist claimed the 95% of the universe said to consist of dark matter and energy (currently accepted) is an artefact of the big-bang theory, but that our observable universe is, in fact, an artefact of the real and actual universe, making what we can observe the actual artefact [15]. The implication is that big-bang theories result in very strange events. Who can know? This is very far beyond anything understood or observable. This makes some knowledge conjectural, yet some conjectures fit into a theory. At their base, theories really need to be little more than believable explanations. However, for many theories, followers require little more than acceptance of authority. At their logical height, they follow rigorous rules of inference such as in classical Euclidean geometry. Even in psychology such a program has been attempted [16]. Notwithstanding the definition above, "Theory" is not a single, uniquely understood concept. For instance, we all have various personal theories, sometimes based on a single experience. I have many. In addition, we find local theories that apply to a group, tribe, or culture. On a larger scale, one finds social and scientific theories, which distinguish themselves considerably in methods and results. For the former, we are confronted with qualitative methods; for the latter, we mostly rely on quantitative methods. We are accustomed to thinking that there should be but a single theory, *the theory*, of a given genre or phenomena. This is not so. There may be multiple competing theories, with conflicts based on approach, hypotheses, and methods. For example, there are four basic categories for learning theories, those based on behaviourism, cognition, humanism, and social considerations – not to mention multiple theories within each.

Now expand the notion of theory by what the terms mean and actually don't mean. A theory is a structure, a container, for an explanation. Better theories also predict. What is meant or inferred by the simple terms, explanation, hypotheses, logic, and evidence, has a multitude of variations. When it comes to the meaning or formation of a theory, just about anything goes. Consider just a few of them in Table 1, arranged by categories and then by examples under the heading. This list includes numerous possibilities the practitioners of one theory would not accept, but upon only a brief examination of theories reveals these many techniques. Mankind has been using theories even before the advent of language. Simply the process of hunting requires heuristics, experience, anecdotes, deductive and inductive reasoning. These theories include and require information about weather, tracking, odour, risk, and proximity. The outcome, i.e. the explanation and result, is the kill. Successful hunters are well possessed of a theory of hunting. It illustrates the application of deduction and induction, together with heuristics and a measure of common sense. At another pole, a multi-value logic, not familiar to most of us, may not generate firm results, but to those involved with solving the so-called wicked problems [17-20] use these logics often. Many theories in the social sciences rely on analogy and consensus often because hard data are unavailable.

Table 1. Components of a Theory

A Theory is a Structure to			
Explain	**Based on Hypotheses**	**Using Logic**	**Using Evidence**
Explanation	Axioms	Deduction	Experiment
Prediction	Common Knowledge	Induction	Prior results
Proposition	Givens	Abduction	Anecdotes
Result	Assumptions	Fuzzy/Multi-valued	Testimony/Consensus
Conclusion	Postulates	Common Sense	Statistics
Solution	Superstition	Analogical	Facts
Clarification		Metaphorical	Analogy
		Correlative	Experience
		Repetition	
		Heuristics	
		Testimony/Consensus	

As a note, and in the admission of the flaws in most theories, many of the aspects of theories are discussed using metaphorical language and some with analogies. Neither measures up to strong deductive rigor. As well, theory is not without its share of vagueness. Some practice a theory through procedures without understanding it, thus placing understanding somewhere above knowledge. Yet, some understand a theory, such as the law, but would be hopeless at practicing it. For example, note the atom of data, the molecule of information, the compound of knowledge, and the chemistry of wisdom. As with all metaphors like this one, they are both a transformation and projection of reality. Inaccuracy is certain. However, the relations are explanatory and usually not entirely incorrect. As we will see presently, the metaphor is just one of aspect of theory – at least some of them. The metaphor and its cousin, analogy, are most important tools for explanation, and specifically for converting information into knowledge. However as intended, they can over-simplify complexity [21-23]. Some theories are little more than methodologies (earthquake prediction), some are fully conjectural (philosophy), some are practical (medicine), some are legislative (the law), many are temporal (psychoanalysis). and so on. The variety is without limit. Literary theories, for example, do not involve prediction but explanations and comparisons. As well there are conceivable theories that do not exist. Literary theory of sports columns is one example. So, while there are many thousands of theories, there are even more thousands of theories that could but do not exist. It is supposed that many more theories are invented or contrived each year than words added to the Oxford dictionary. Each has its own rules of reason.

COMPARING THE DIKW AND DITAT-W HIERARCHIES

In fact, the DIKW and DITAT-W hierarchies are probably better called frameworks, because the relationship between levels of each is not strict. For example, not every datum is part of some information. Some knowledge may not be a component of wisdom. Some theories may not fit into an area. This applies to all the levels in both hierarchies. Knowledge in the DIKW hierarchy or framework is properly a part of epistemology. Plato [24] began this study, at least in the ancient literature. Over the intervening centuries, philosophers such as Descartes [25] and Kant [26], and many others have struggled with the meaning of knowledge. From Popper, knowledge is inextricably bound up with belief, and the verb form, "to know." [27]. The shadings of knowledge are endless. For example, these are different: the knowledge of truths and knowledge of things [28]. Knowledge, like ethics and morality, are among the topics philosophers love, as they can ruminate for centuries upon them, never coming to either a clear understanding or consensus. A simple consequence is revealed in the view that defining knowledge is or must be an impossible problem owing to its vague and/or multifaceted definitions.

The original Sorites paradox, dating from antiquity [29], applies here. This paradox arose when adding grains of sand, one by one, until the total becomes a heap (of sand). In application to the DIKW pyramid, we inquire as to the transitions. The DIKW, being posited as a hierarchy, indicates states. When a transition between states is involved, such as data to information, information to knowledge, or knowledge to wisdom, a basic question is when the transition occur? For example, begin with some information, add data, unit by unit, until it becomes knowledge. At what point does this happen? This problem is impossible, partly because of scale, meaning the scale of data may be microscopic relative to information. Can it be numbers of data? Also required is the necessity to understand the process by which the conversion takes place. Do we convert (information to knowledge) because of a guideline, i.e. a theory, or is there some magnitude of information where the transition takes place? These make the prospect of quantification dubious. In an important sense for the DITAT-W hierarchy to regard that knowledge (the K) dissembles into the theory, area, and type (the TAT). We simply call the components of a theory, explanations, hypotheses, logic, and results knowledge *a priori*. In brief, K trifurcates into TAT, where it is acknowledged that theories have many forms, some containing knowledge that other theories would not accept. This implies that K is not only disjointed but plural. Embedded in both hierarchies is the notion of process. Process, itself, is multifaceted. However, theories set out process rules for themselves. They are substantially linked with hypotheses and logic, with the former setting out what is accepted without proof, and the latter allowing what type of explanations are admitted. Now process is not strictly a human endeavour. With machine learning, we have computers accessing "data lakes" busy constructing knowledge, which in turn informs theory. The question is again on the nature of knowledge. If a computer generates some conclusions, is it actually knowledge, or maybe some type of alternative information? One projection of this is to say that knowledge for the one may be only information for another. At the other end, knowledge for the one may be an operational law for the other. Knowledge is a broad-band concept.

THE DOUBLE EXPONENTIAL MODEL

The tool used to quantify or model is the DITAT-W pyramid is the **double exponential** function. That is, the exponential of an exponential. So instead of r^j we will use r^{n^j} as *j* ranges over the integers from 1 to the number of levels, which in the present situation is six. This is a model not used much in application, though it has some applications within mathematics such as the determination of what are called Mersenne primes. It allows fantastical growth as we see in the conversion of data into information and then to theories, and the like. It has been applied to population dynamics to the growth of human population is sometimes supposed to be double exponential [30]. As well, it has been applied in physics [31]. Both applications are recent, in the last decade or so. In our applications, we have the levels, $j = 1, \ldots, L$. We conjecture what *r* and *L* should be to make the growth reasonable and justifiable, noting the levels in the DITAT-W model, while well- defined, are not associated with numbers at all, except for data. For instance, how much information does it take to generate a theory? How much information or how many theories can be borrowed? What is the range of information content of a theory?

Such questions must be regarded as having unknown answers if only because they vary so much. When does a body of theories constitute an area? And what is a list of types of areas? All these are unknown. Here we merely suggest a starting point.

Why the double exponential? Partly because it is the most simplistic model that exhibits reasonable results. The input to the model includes the base *r*, the number of levels *L*, the exponential rate *n*, and the total amount of data *N*. Only for the data are there reasonable estimate, which we take here as 10,000 zettabytes. (A zettabyte in magnitude is a 1 followed by 21 zeros. (In fact, this value is ten yottabytes – big.) This is an estimate derived from a Cisco report [10] which offers an estimate of 10 zettabytes created per year by 2020. However, the report also indicates several highly data intensive trends in the formation of information including the growth of smartphones, internet gaming, virtual reality, immersive video, and video surveillance. Moreover, this is an annual figure, not the total overall. Our working value of 10,000 zettabytes is an

Table 2. *n* = 2.33 with six levels

Rate = 2.33	Levels = 6	r=3.87	
Name	Level	Value	Order of Magnitude
Wisdom	1	1	0
Type	2	3.87	1
Area	3	904.15	3
Theories	4	4.02E+07	8
Information	5	7.31E+14	15
Data	6	1.00E+25	25

estimate based upon an estimate. We select values for *L*, namely $L = 6$, and *n*. Call *n* the *rate*. From the model, compute *r* from $r^{n^L} = N$. The solution is:

$$r = \sqrt[n^L]{N} \tag{1}$$

Alternatively, we could have defined *r* and solved for *n*, though it is easy to see there must be the relation $n^L \ln r = N$ between them. We look at three values for the rate, *n*= 2.0, 2.33, and 3.0. In the tables below quantities at each of the levels is considered. It is best to base further discussions on the orders of magnitude, at least for the very large numbers involved. In Table 2, we take *n* = 2.33. Orders of magnitude are expressed in base 10. From Table 2 we read that there should be about four types, 904 areas, 40 million theories, and so on. Are there really that many theories? Keeping in mind the hundred thousand or so of academic theories, thousands of business theories, and several million operational theories, basically, unofficial theories by which everyone lives, it may not be unreasonably large. Interpretation is paramount. The value for Wisdom is selected as one for all tables. In the formula, for level *L*, use the value *L-1*.

From Table 2, it seems that about $10^{10} = 10^{25} / 10^{15}$ data are required to create one informational statement. This is unreasonably large. However, note that much data collected, thought, visualized, or otherwise created is never compiled into information. It is just there. Similarly, the table gives us that about $10^7 = 10^{15} / 10^8$ informational facts fall into a single theory. This is reasonable when one considers the hundreds of thousands or millions of facts that comprise some of the major theories. Yet again, much information is not properly contained by any theory. It is just there as *orphan* information, as it were. Finally, the table yields that $10^5 = 100{,}000$ theories can be placed within an area and 100 areas comprise a type. These values are large, but reasonable. For example, in a large university, one hundred departments are common. Indeed, it is possible to develop for a given theory dozens of *sub*-theories. These follow a stricter hierarchical tree. Putting that aside, in each discipline, there are at least one hundred theories, and probably multiples of that. Adding the thousands of theories outside the academy brings a total in the range given by the model. Similar interpretations apply to magnitudes in
Tables 3 and 4. Table 3, with *n* = 2.0, shows many more theories, about one billion, which renders one theory for every six persons on the planet. This seems a bit high, but is it? Everyone has personal theories about living, social interactions, travel, and the countless activities of life. Naturally, tuning the model has value.

Table 3. n = 2.0 with six levels

Rate = 2.0	Levels = 6	r= 10	
Name	Level	Value	Orders of Magnitude
Wisdom	1	1	0
Type	2	10	1
Area	3	10000	4
Theories	4	1.00E+09	9
Information	5	1.00E+16	16
Data	6	1.00E+25	25

Table 4, with n = 3.0, gives only 40 areas, and about 10,000 theories per area. This appears to be more reasonable. It also indicates there must be much more orphan data, also reasonable. The rates were selected to illustrate a range of possibilities. The most important point to note is that vast orders of magnitude separate the categories, more so at the data end of the DITAT pyramid than the top. As well, many the bottom three categories (data, information, and theory) can only be called *orphan*, not fitting into the next higher group – unless expanding the number of areas is desired. Big numbers required an expanded view of all there is.

Finally, note the orders of magnitude roughly track the square of integers pertaining to the level. Of course, this is not particularly insightful; it is part of the model. So, which of these is correct? All of them and none of them is the answer. The model posited given constructs valued based on very large numbers winnowing down to the very small. It illustrates the transition from data to wisdom is highly variable, and cannot be easily dismissed by any qualitative means. It is the quantification that reveals aspects of the DIKW analysis that have previously not been discussed. It is rare such a simple model can be so effective, but other rapidly growing models do exist. One possibility is the factorial model based on values 1!, 2!, 3!, …, L!. While growing faster than exponential, it grows too slowly and it is doesn't register to come out given the data value is known at the L^{th} level. With generalized factorial progressions, one can obtain big numbers, but there seems no reason for pursuing such an arcane model. Additionally, it would be necessary to use the (generalized) Gamma function to assure the correct value of data.

Table 4. n = 3.0 with six levels

Rate = 3.0	Levels = 6	r = 1.58	
Name	Level	Value	Orders of Magnitude
Wisdom	1	1	0
Type	2	1.58	1
Area	3	39.81	2
Theories	4	251189	6
Information	5	6.31E+12	13
Data	6	1.00E+25	25

With the Gamma function, competitive divisions can be obtained, as a cost of finding the rate r, which must be done numerically. Another possibility is to use of the triple exponential:

$$r^{s^{t^j}}, j = 1, 2, ..., L \quad (2)$$

where r, s, and t are to be specified. This model grows too fast. Using it would also yield rather small values at the top of the DITAT pyramid. In sum, the double exponential seems just about right. Suppose we wish to eliminate all the data that will never become part of the DIDAT-W or DIKW pyramids. An estimate is needed. Let us suppose only 10^{13} data are viable toward this end. Applying the same method as above we obtain the fractionations as shown in Table 5. With only 10 trillion data points to process, the model indicates there are only 20 million statements of information to be compressed into about 48 thousand theories, which comprise about 120 areas, and so on. The mind is more facile with lower values. Surely more data is processed into information each year. With over 130 million USA tax returns filed in 2016, each containing at least 100 data points, with billions of bills delivered, this already approaches multiple billions of data just in the United States, it seems 10 trillion data points is rather low. In fact, the social security records, alone, easily exceeds this value, if viewed as individual data.

Table 5. Using data points with rate 2.0 and six levels

Rate = 2.0	Levels = 6	r = 10	
Name	Level	Value	Order of magnitude
Wisdom	1	1	0
Type	2	3.311	1
Area	3	120.25	3
Theories	4	47863	5
Information	5	2.09E+08	9
Data	6	1.00E+13	13

Finally, we consider the case where the amount of data is reduced to 10^{21} data points, a single zettabyte of data. This is just one tenth of one year's data estimated for 2020. The results are shown in Table 6 for the same three rates, *n*= 2.0, 2.33, and 3.0, as previously considered. These magnitudes appear more manageable, but they reflect previous observations with many orders of magnitude separating successive levels. Therefore, in all cases, there must be many orphans at each level except the very highest. For example, the order difference is from seven to ten in transitioning from data to information, and for the transition from information to theories the difference in orders is six. Again, the requirement of 10^{13} statements of information to generate 10^{7}theories is high if the hierarchy is strict. It is not.

CONCLUSIONS

This entire quantitative enterprise of placing values to levels of the hierarchy illustrates sheer orders of magnitude must be used when analyzing massive data, and alerts the observer attempting generate a quantification for the original DIKW container, for which the four levels may be too small. It would have far greater magnitude ratios with the same amount of data used. The model used here is simple; Excel can easily make these computations. It must be concluded there are countless orphan theories, information, and data as top levels of the DITAT container are reasonable. Of course, big data efforts are collecting data into information with algorithms suggested by theories, creating more of all at an exponentially increasing rate.

Table 6. 10^{21}data with six levels.

	Levels = 6	Rate = 2.33		Rate = 2.0		Rate = 3.0	
Name	Level	Value	Order	Value	Order	Value	Order
Wisdom	1	1	0	1	0	1	0
Type	2	3.12	1	6.92	1	1.47	1
Area	3	304.26	3	2290.87	4	22.08	2
Theories	4	2.44E+06	7	3.63E+07	8	34355.8	5
Information	5	3.06E+12	13	2.75E+13	14	5.65E+10	11
Data	6	1.00E+21	21	1.00E+21	21	1.00E+21	21

If it is desired to discuss what levels in this hierarchy are important, it can be agreed that all types and areas are important, and many of the theories. Almost no information is generally important without a theory – except perhaps to individuals or special groups. This puts us about half-way up the hierarchy levels. This is not uncommon in hierarchical settings. However, it is easy to determine the Lotka-Price square-root [32] rule does not apply as the growth is too rapid. As final note, one might consider a seven-level pyramid, with knowledge placed between information and theory. However, knowledge is a relative quantity, such as facts becoming knowledge on the basis of relevance.

Nonetheless, it would allow knowledge with its own category, dramatically reducing the number of orphans. This is an aspect also of the DIKW hierarchy, but when no values are applied, it remained unnoticed.

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