STRATEGIC ALIGNMENT OF INFORMATION QUALITY: ACADEMIC AND PRACTICAL VIEWS

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Abstract: This paper focuses on the problems of aligning information-quality management to shifting strategies or operations, including political, military, and business strategies; it illustrates how substantial shifts in strategy may change the objectives, focus, scope, and priorities in assessing how information quality impacts the results of operations, which are the main components of information quality management. Thus interpreted, strategic alignment requires articulation of some additional concepts and distinctions that can be ignored only at one's own peril. They belong to the natural semantics of operations where meaning is measured by materiality of the difference in results (with regard to their purpose), which are affected by the proposed distinctions. Of course, as part of language, they may be analyzed semantically, but this is a separate issue.

Key words: Alignment; operations strategy; information-quality management: scope, focus, and priorities in assessing quality; primary information; secondary information; actionably reliable data; factual nature of data

INTRODUCTION

There are many approaches to assessing quality of information (IQ) [11, 16, 25, 28, 32, and 33]. Usually, assessments are conducted under the assumption that increased quality is beneficial. This assumption suffices for the initial phases of studying information quality. It holds true as long as economy and efficiency are not yet at the front burner, but economy is a law of nature. Organizations and societies that economize gain competitive advantage over the less efficient. A cursory overview shows an emerging trend of studies that refer to economic aspects of IQ. For instance, "utility value" of data or information in [10]; "economically driven," "utility driven," or "economics driven" in [3, 8, and 9]; "optimal approach" or "efficiency approach" in [20, 21]; and "materiality of information quality" in [16]. It is a sound and welcome trend. The Conference Chairs of the 16th ICIQ challenged prospective contributors not only with the theme, "Organizational Value through Quality Information," but also asked for "Alignment of IQ with Business Strategies." One may ask why it is limited to business strategies only. This paper illustrates how challenging such an alignment may become. This is a call of a higher order than economy of IQ improvements; it poses new problems.

One needs information-quality management systems (IQMS) that are flexible enough to make possible their embedding in any defined situation (circumstances) including selected philosophies or strategies of operations. It changes information-quality use requirements and the priorities in assessing them. It requires measuring the impact of information quality on the actual plan of operations and the targeted results. Improvements of information quality must be aligned with the overall vision of operations, their

purpose, management philosophy, critical success factors, goals, and how the results will be measured. These are the essential elements of strategic management. This paper

1. shows the challenges IQM faces to become flexible enough for its effective embedding in and subordinating to any different philosophy, theory of operations management, or strategies. (It does not necessarily render useless the many generic methods and techniques already developed; however, they must become flexible enough to narrow their scope and focus on critical success factors as defined by different strategies.)
2. provides an overview of how information, data, and other elements of knowledge may affect operations.
3. enumerates the necessary information-quality use requirements and the shifts in priorities of analyzing them.
4. suggests a few extensions of our current vocabulary in information-quality studies with additional operational distinctions that cannot be ignored by IQMS that are aligned with shifting strategies.

There are not many aspects of information quality that are intrinsic to information; actually, most of them are use requirements. The rather generally accepted definition of information quality as "*fit for use*" needs some further elaboration to clarify what it actually means. The best one seems to be the one paraphrased from [29]: ***"Users' quality of information** is an aggregate of their entire experience at all the touch points related to its use.*" A ***touch point*** may entail one or more aspects (dimensions) with related use requirements. Use requirements pertain to physical aspects of factors and the needs and expectations of their users. Ultimately, it boils down to information use requirements that may differ substantially, depending on the selected strategy and the circumstances under which they serve.

The paper is presented for challenge, critique, and discussion of its substance. Most reviewers focused their attention on the presented background, thoroughly reviewed literature, form, and style, which, of course, are important but fail to address the main point of my argument. For focused reading, key terms in paragraphs are in **bold** print, and emphasis is in *italics* or CAPS. Terms accompanied or followed by a definition appear in ***bold italics***.

HOW MANAGEMENT THEORIES MAY AFFECT INFORMATION NEEDS

Philosophies and theories of management provide mental and/or formal models of operation. Models determine the factors of operations that are deemed necessary and significant in attaining the purpose. Among them are ***factors in form,*** such as information, data, and other elements of knowledge that include relationships and rules of reasoning and proceeding. Like other factors, they must meet categorical and situation-specific use requirements. The acronym IQ serves here as the shortcut for the quality of any kind of factor in form, as defined before. According to some reviewers, a "*focus on operations does not provide evidence of effective alignment with strategy nor on the specific role of quality."* We posit that, if quality does not impact results of operations with regard to their purpose and requirements, practitioners will not be interested in discussing such concepts of quality.

For instance, Gupta and Boyd [18] propose the theory of constraints (TOC) as a general theory in operations management. Within TOC, Goldratt [17, p. 19] identifies three fundamental questions regarding how much money a company generates, captures, and spends:

1. ***Throughput*** is the rate at which fresh money is generated through sales minus the amounts paid to vendors and other providers for the items that went into the product sold [17, pp. 19–22].
2. ***Inventory*** is all the money used to purchase the things the system intended to be sold, including machines and buildings [17, p. 23].
3. ***Operating expense*** is all the money spent on turning inventory into throughput [17, p. 29].

Goldratt [17] demonstrates a stark difference between the "cost world" and the "throughput world." In the *cost world*, factors are of equal importance if they are of equal cost. He mocks, "*Focus on everything and you have actually focused on anything*" [17, p. 58]. It is difficult to focus in the cost world. Cost-savings measures are proportionate and always limited by zero. One or more changes do not change much in the cost world. Total Quality Management (TQM) even encourages nonfinancial measures [17, p. 55] that are not directly related to the selected business strategy and the purpose of operations. Thus, at best, TQM is an IQM only weakly aligned with business strategies; weakly in the sense that general improvements of IQ are, to some degree, beneficial with any strategy as long as the incurred cost of improvements does not nullify the benefits.

In contrast, the *throughput world* is open-ended and limitless. By its very definition, it is always focused on that which we do not have enough of; that is, on the weakest link—on the **constraint** that limits performance of operations and their targeted results. The theory of constraints articulates a clear paradigm procedure within an infinite loop of ongoing improvements, where a change of one constraint changes everything and likely with multiplying effects. When management focuses on a new constraint, it also moves the focus on quality requirements from one set of information to another and from one set of quality requirements to another, but the situation is always unambiguously defined.

For instance, in the *cost world*, increasing processing time and the related cost of one task without offsetting it by a similar decrease of a different task of the same product makes no sense. It contradicts the fundamental principle of the cost world; it will be instinctively and rightly resisted within a strategy of cost containment. This, however, may not apply to other strategies. In the *throughput world*, a total increase of processing time on nonconstraint resources to offload the constraint resource may be highly beneficial when measured by the company's overall throughput (fresh money). TOC provides cohesive and dynamically changing guidelines for ongoing improvements and criteria for assessing the locally relevant quality of factors in form. Only the processing time on the constraint resource needs to be accurate. The accuracy of the remaining processing times does not matter much, while in the cost world, striving for better accuracy was a way of life, as innumerable studies confirm, among them being one of the most significant by Wang and Strong [30].

With TOC, one easily derives a hierarchical set of criteria that directly contributes to the overall purpose of operations. "*If the latter means making more money, every measure must have a $ sign*" [17, p. 55]. By the same token, any local measure must be of the same unit as the main purpose but excluding the related cost. The *throughput world* defines clear boundaries within which quality improvements matter. Going beyond them does not improve the end result [17, p. 84]; expenditures on quality improvements that DO NOT sufficiently contribute to the results of selected strategies deteriorate the overall efficiency of operations.

Thus, the decision process within TOC is very different. Redefinition of goals changes the nature of the required data and their corresponding use requirements (e.g., *accuracy*). Let us take another example. Goldratt asks why we need the "product cost". We need it to decide which one should be pushed and which one we should refrain from pushing to the market. All cost systems would prefer products with a higher profit margin, while the bottom line measured by throughput (fresh money) suggests just the opposite (i.e., lower unit price and profit but higher volume). He summarizes it this way: "*The concept of product cost together with the decision process from the cost world should be eliminated*" [17, p. 14]. Thus, TOC changes the decision model, the required data (factors in form), and their use requirements. It illustrates the profound changes an IQM system must undergo to become aligned with a selected strategy.

The above demonstrates how decision-making, required data and their quality directly depend on shifts in philosophy, theories of operations management, and the selected strategies.

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WHEN STRATEGY SHIFTS HAPPEN

Most studies of IQ, if not practically all, focus on data in databases and warehouses. It is natural because quality deficiencies in this domain are the most acutely perceived. These data suffice for routine business operations. With the exception of nonaligned legacy information systems or neglected operational databases, the problem of IQM alignment with business strategies arises when management feels the need for a major shift in the current strategy. Such decisions are never made based only on data stored in organizational databases; rather, they are made on data gathered by business intelligence and not yet incorporated into the current databases.

Shifts in strategies are caused by major changes in the business environment that are not yet part of current data-collection procedures but are the subject of business intelligence. By their very nature, they represent exceptional and only potential needs in contrast to the routinely collected data of familiar roles, where their operational interpretability, relevance, meaning, on-site and on-time availability, actionable reliability, and other situation-specific necessary-use requirements are fairly familiar and stable. Alignment of IQM with strategies poses qualitatively different problems; IQM must expand beyond the already available data and focus on information gathered by business intelligence. The latter brings to light significantly more elaborate quality problems. The role of routine data is familiar to those who act; hence, which aspects of quality within the entire quality space require attention is usually well understood. When it pertains to information gathered by intelligence, both their potential role and which aspects of quality actually matter are highly uncertain. What is nearly obvious about the quality of routine data is highly uncertain for information gathered by intelligence.

Here we face a wide disparity of views with academic reviewers. One says that "*one must accept the premise that all strategies are operationally driven*," which contradicts reality. All operations, if planned (not spontaneous reactions), are conducted (hence driven) according to agreed strategies. Two classic examples are (a) The German Schlieffen Plan to automatically invade France with full force when Russia and France mobilized; otherwise, Germany would be overrun from the East and West at the same time. This strategy triggered WW1; and (b) Britain's unconditional guarantee for Poland that, if attacked by Germany, Britain would declare war on Germany. This strategy, the worst in Britain's history, triggered WW2 and the loss of its Empire. Two academic reviewers suggest dividing the presentation into two separate parts, as if the heightened assurance of information quality were unrelated to shifts in strategy. Strategic alignment of information quality may become effective only when it assures actionable reliability and the factual nature of data used for this purpose; it is much more challenging, as the short cases presented later illustrate.

Quality problems related to strategy require additional distinctions that, given a shift in strategy, one may ignore only at one's own peril. For instance, in most IQ studies, authors use the term "information" interchangeably with "data." Both are factors in form in routine operations. As long as they refer to the same entity, their aspects of quality are the same, and their assessment is unaffected by such a distinction. Now, however, we face a problem that is not discussed in the literature a problem of primacy of informing and information over data and the distinction of primary and secondary informing (Table 1).

PRIMACY OF INFORMATION OVER DATA; PRIMARY AND SECONDARY INFORMING

Humans (researchers, observers, intelligence officers) communicate with their surroundings by passing patterns of signals via their sensors, supported or not by instruments. Patterns may be in **substance** or only **in form** of no other role on their own. In common parlance, anything in form only is referred to as information. The obtained original patterns in form, in short **originals**, constitute the ***primary***

Table 1. Primacy of Informing and Information over Data: A Simplified Conceptual Scheme of Their Flow

1	**Primary informing**	Research and/or observations that yield the initial **primary information**
2	**Primary information**	Subject to quality management or **quality assurance** of **usability** of information items that must be operationally **interpretable, relevant**, **meaningful**, **significantly material**, **on-site available**, **on-time available**, **actionably reliable** (credible and/or actionably believable), and meet **other necessary situation-specific use requirements**. If it does not overlap with other information, it changes the situation triggering a state transition, its model, the entropy of the system, and is associated with a NON-ZERO amount of information, as defined by Shannon and Weaver (1949).
3	**Data**	Subject to applicable procedures **deemed necessary** (e.g., *court procedure, FDA approval, registration in the Patent Office, Generally Accepted Accounting Principles, Generally Accepted Auditing Standards*, etc.) that are aimed at **establishing the factual nature** of the scrutinized primary information; i.e., showing it is worth preservation and storing it in databases as actionably reliable factors in form.
4	**Secondary informing**	**Dissemination** (passing, sharing, spreading) information and/or data by the primary source and/or other subsequent intermediary sources to interested researchers and users (clients). All of them, as not yet available and known, are perceived by recipients as **secondary information,** with the same consequences for the clients as the primary information for original researchers and observers.
5	**Secondary information**	Information obtained from other than the original sources is of a second-hand nature and, thus, is vulnerable to distortions and misinterpretations. It should be subject to **secondary quality assurance,** whether it is **valid** or at least **acceptable for subsequent use.**

information acquired by the process of ***primary informing***. They are usually converted to different patterns (their **images)**, which are more suitable for registering, recording, and/or memorizing. Images represent the originals at some degree of fidelity. One expects them to be factual; they should represent facts.

Now, however, we face ambiguities even in dictionaries that allow a fact to be equivalent to "information presented as objectively real" (AHTD) or "information presented as having objective reality" (Merriam-Webster Dictionary). Within the context of the studies of information quality, it is unacceptable because in real life, even outright disinformation is presented to appear to be true. ***In this study, we separate entirely objective reality from its representation.*** All intelligence agencies run less or more elaborate disinformation services; therefore, we stick with the simplest interpretations. In dictionaries, with regard to objects, a "fact" is "something that has actual existence" (Merriam-Webster Dictionary) or "Something having real, demonstrable existence" (AHTD). With regard to events a fact is "a real occurrence" (AHTD) or "a thing done"(Merriam-Webster Dictionary). Within the context of operations, however,

contingencies that do not yet exist or have not yet occurred but are operationally possible should also be treated as factual factors in form (e.g., *explosives that may explode*). All of the above can be summarized for the purpose of this study: ***Facts*** are things that exist, events that occurred, or contingencies that may occur. Organizations never or rarely store facts, particularly with computers; they mainly store symbolic representations of facts.

The first and foremost purpose of primary informing is to gather and ensure the **usability** of the primary information, including its factual nature. Usability should be accomplished by whatever acceptable procedure is deemed sufficient, called **quality assurance**. Quality aspects, usually of high interest for routine data (accuracy, precision, etc.), are now of only secondary concern. Primary information, particularly for strategic purposes, needs to be of effective ***operational usability*** that includes actionable reliability. Such an assertion requires a tedious process of quality assurance of incomparably higher rigor than practiced for routine data. This is the way primary information becomes ***actionably reliable data*** of a confirmed factual nature. How difficult and convoluted this process may become is illustrated in the next section about the chasm that may separate primary information from actionably reliable data.

Effective usability of operational factors in form entails operational interpretability, relevance, meaning, significant materiality, on-site and on-time availability, actionable reliability (believability and/or credibility), other task- and situation-specific use requirements, and, finally, its operational completeness with other necessary usable factors for effective action, as defined in [21]. ***Operational completeness,*** as task specific, is an entirely different concept from completeness of rows and columns in database tables or completeness of mapping of objective reality into states of information systems. Current studies of information quality use only the last two kinds of completeness. Within the context of operations, this is a serious omission.

Finally, factors, to become ***operationally useful,*** must

1. be effectively operationally **usable,** as defined above;
2. meet the necessary primary (categorical) use requirement of **operational completeness** (e.g., *location* and *time* for an effective drone attack) of a **direct task** or a task that triggers a ***direct task*** (that directly contributes to the main purpose of operations); and
3. be actually **engaged** in operations; otherwise, they are ***usable factors in waiting***.

Operational usability, completeness, and usefulness of factors are of material consequences, not quite a subject of linguistic semantics. This eludes academic reviewers. They suggest reaching out, among others, to Bertrand Russell, Ludwig Wittgenstein (who contributed to logical truth and linguistic semantics), and even to computer science and software engineering for "*a stronger philosophical and foundational basis for this analysis.*" They suggest separating the subject of strategic alignment from "*a number of diversions into detailed semantics that distracts from the clarity of the presentation.*" Academicians immersed in linguistic semantics ignore consequences of operational semantics that, in military and business operations, overrides the former, when "operation peace" may mean a vicious "pacification" of a village.

Thus, the focus and scope of an IQM system, aligned with strategy, changes dramatically. For a strategy to be effective, the operational quality of all factors requires a substantially extended quality assurance. Then items of operationally usable primary information that are considered of a broader and more lasting use will be stored as **actionably reliable data** in databases and data warehouses, initially by the original researchers and observers. Hence, our familiar data are subsets of usable primary information, nothing more and nothing less.

Researchers, practitioners, or users not involved in the process of primary informing must acquire those data labeled here as ***secondary informing*** (communicating, reading, analyzing, etc.). This way, data are

spread from the original researchers or observers to others. MIS textbooks ignore such distinctions. They oversimplify the situation by reducing the entire problem to **secondary informing;** in glossaries, they define information as something derived from data gathered, collected, verified, and validated by others.

A CASE OF A POSSIBLE CHASM BETWEEN PRIMARY INFORMATION AND ACTIONABLY RELIABLE DATA

It is a case of WAR, PEACE, and POLITICS played by individuals who are educated in elite war academies such as experts in intelligence communities, members of the Joint Chief of Staff, and political commanders-in-chief of one former formidable power and another current world power drowning in debt. Ultimately, the distinction between primary (or initial) information and actionably reliable data has been ignored.

The leadership received intelligence information about the accumulation of weapons of mass destruction (WMD) in Iraq, information that was provided by ONE defector, which was denied by his former boss, while military intelligence flagged the original source as UNRELIABLE [5]. Without additional corroborating evidence, this information was either accepted or presented as a fact, an actionable datum for the United Nations and two chains of command up to the top two commanders-in-chief. After the fact, this defector revealed that he made up the story. Intensive on-site scrutiny with no WMDs found corroborated his confession.

Academic scholars consider this a "*controversial example because it happened during war and the explanation is rather political and has no relation to the claims mentioned in the paper*." First, it did not happen during war, but served to justify war. Second, it suggests that business strategies are not subjected to political pressure which is contrary to reality (e.g., *bailout of General Motors, banks, and insurance companies with tax dollars, tax loopholes available to them. General Electric had no tax liability for the entire year*). Third, one must be intellectually blind not noticing that unreliable data insufficiently scrutinized have no relationship to alignment of information quality with political, military, or business strategies.

A wide chasm may exist between **primary information** and **actionably reliable data**, a chasm that can be bridged only by tedious verification, scrutiny, and validation, called **information quality assurance** that is a key component of all information-quality management systems. Shifts in business strategy heavily depend on business intelligence that should be scrutinized with the highest rigor. It seems obvious to practitioners without abstract considerations.

FACTS AND DATA—A FUNDAMENTAL DISTINCTION

In MIS textbooks, one finds a plethora of views about facts and data that represent them. See the following samples:

1. *"DATA: Any string of characters that describe something about reality,"* by Goldratt [17, p. 85].
2. "*Data consists of facts and figures that are relatively meaningless to the user, while information is processed data, or meaningful data,"* by McLeod [26, glossary, emphasis added].
3. *"Facts, images, or sounds that may or may not be pertinent or useful for a particular task,"* by Alter [1, glossary, emphasis added].
4. *"Raw facts that can be processed into accurate and relevant information,"* by Turban et al. [31, glossary].

5. *"Raw facts that describe a particular phenomenon,"* by Haag and Cummings [19, glossary].
6. *"Streams of raw facts representing events occurring in organizations of the physical environment before they have been organized and arranged into form that people can understand them and use,"* by Laudon and Laudon [24, glossary].
7. *"Facts or observations about physical phenomena or business transactions. More specifically, data are objective measurements of the attributes (characteristics) of entities such as people, places, things, and events,"* by O'Brien and Marakas [27, glossary].
8. Data are *"Recorded, unformatted information, such as words or numbers, which often has no meaning in and of itself,"* by Jessup and Valacich [22, glossary, emphasis added].
9. *"Recorded facts or figures. One of the five fundamental components of an information system,"* by Kroenke [23, glossary].
10. "*Data—Raw facts that describe the characteristics of an event or object,"* by Baltzan [3, glossary].

With the exception of item 8, all authors agree on the *factual* nature of data; however, they refrain from explaining what facts are (see the section about Primacy of information). Many (too many) authors take the liberty of listing side by side on an equal footing, *facts* with *figures*, *images*, *sounds*, *words*, *numbers*, *observations*, and/or *descriptions* of facts (see items 1–10 except 1 and 8) that may only represent them. In practice, this ambiguity may yield disastrous outcomes.

Fisher et al. [11] describe the attack by the USS Vincennes on the Iranian Flight 655 that took many lives, resulting in apologies, damage control, and payments for damages. The ship's captain stated that they had only four minutes to act—insufficient time to verify the alert as a fact versus a false positive. It turned out that their defense system was reusing code values for different levels of potential threats. The code value (a symbolic representation) once pointed to or referred to an approaching dangerous warplane (a factual lethal danger), while, at the time of the event, the same code value referred to a commercial airliner (a different fact of no danger to the warship). This is an example of a possible chasm between a fact and the data value that should represent that fact, a fundamental distinction that can be ignored only at one's own peril.

When the lack of this distinction was pointed out, authors, reviewers, and even editors asked not to take definitions too literally. Academicians enjoy the luxury of introspection and multiple reflections before they put something in writing that is not yet in action. Most of them never had to bear the responsibility of producing a defined result under a deadline in a high-pressure environment (e.g., *to avert an attack, to assure financial stability of a business unit*, or only *to participate in hypothetical war games*). Professional experience in running a business or other operations is rarely listed among requirements for teaching business courses. In too many schools, for the sake of convenience, business projects as a culminating experience for graduating students have been replaced by a designated capstone course or a comprehensive examination.

In environments that are remote from practice, the difference between facts and figures seems to be a nuisance not worth attention. It is worth pondering the stark difference in defining data by someone deeply immersed in practice—Goldratt (see item 1) and the authors of MIS textbooks being mainly professional academicians. It is amazing that many authors pepper their definitions with statements such as data being "*relatively meaningless to the user*" (item 2), "*that may or may not be pertinent or useful for a particular task*" (item 3), or "… *which often has no meaning in and of itself*" (item 9). They suggest that users (practitioners) collect meaningless data, which makes their quality assurance impossible and renders the data redundant. Thus, they desensitize student minds (future users) with regard to their responsibilities. Future users, rather, need "sensitivity training sessions." On the one hand, individual-transaction data may actually constitute a miniscule fraction of the total business activity of a corporation, while, on the other hand, even a miniscule error, if repeated and multiplied million of times by fast

computers, may lead to serious miscalculations or a downed airliner. A data error, like a loose tile, may cause loss of lives and the entire spacecraft if not detected or prevented.

Attention to details is the foundation of rigorous *information quality assurance*—an important component [Or did you mean "*and an* important component …"?] of IQM aimed at bridging the possible chasm between facts and the data that are supposed to represent them. An instructor, who held MIS students accountable for ignoring that difference, was reminded that he *tortures* rather than *attracts* them to a college education. One might consider the relative pain of a low grade versus losing a promotion or a job when that difference is not emphasized during the student's education.

ALL previously quoted authors (hundreds could be cited) omitted in their definitions the etymology of the terms datum/data as something *given* or already *known*. One reviewer considered this sentence as "evidence that the author is unfamiliar with the current literature." If ten quotations do not suffice, then more will not convince either and science does not progress based on consensus. Who among practitioners needs support from "wider literature and a clear theoretical framework" when MIS textbooks neglect emphasizing the need for the factual nature of data? The same reviewer sees a need for a second paper about information quality in war, as if there were any differences. There is a unity of science. The same principles apply, only in war; the stakes are higher and are deadly. The reviewer is fortunate enough, being spared from two fronts rolling over his head with one fifth of his countrymen annihilated, that he seems not to notice that both cases given in this paper do not pertain to wartime. A similar lax attitude toward data in academia can be found published in otherwise reputable academic journals by known reputable scholars.

Fricke [12] boldly criticized the Data-Information-Knowledge-Wisdom (DIKW) hierarchy. He views it as "*part of the canon of information science and management.*" However, trying to improve on Ackoff, he offered a different view of data: "*When, for example, a person fills in a form giving their name, address, age, social security number—those inscriptions are data. (Actually, the term 'raw data' seems apposite.).*" This illustrates how statements made even by recognized academicians fail the test of reality. Such data should faithfully represent (in form) reality and they should be factual and actionably reliable when they might represent a stolen identity. We feel troubled that such a blunt analysis is necessary, but at stake might have been a $200K (or more) loan. All of the so-called "*inscriptions*" are uncertain primary information (maybe "raw") that are given to a loan officer who should put them through a wringer of quality assurance. The process of quality assurance is absent from all discussion about knowledge management. The data, so mercilessly denigrated in academic literature, deserve plenty of attention before they can be accepted as actionably reliable data.

About the same time (Fricke's critique has been available online since 2007), but independently, **Jean-Baptiste P. L. Faucher** (working on his doctoral dissertation)**, Andre M. Everett, and Rob Lawson** (likely his advisors) [10] embarked upon improving on the traditional knowledge-management models by *reconstituting knowledge management*. While doing so, they proudly state that "*none of the definitions are linked to facts*" [10, p. 12] because facts are considered true, while people are fallible. Fortunately academicians are more fallible than practitioners. Products and services "made in New Zealand" are of known quality. If these academicians were infallible in their statements, we could not rely on anything constructed by humans. In operations, a different approach is used. Whatever is provable or at least replicable is considered of statistically significant reliability or simply operationally true until demonstrated otherwise.

Alas, both examples of academic scholarship demonstrate again how acknowledged reviewers, authors publishing in otherwise respectable academic journals, and even editors of those journals (as with all of us) tend to lower our guard concerning undisciplined thinking about data; data without a defined context, focus, purpose, and perspective from which a decision-making agent views and assesses the situation in

defiance of Blackler's postulates (among others) that all forms of knowledge, particularly data, should be contested [4, p. 1042] to remain actionably reliable.

Omission of the factual nature of data, data given by whom, to whom, or known and assumed by whom deprives the textbook definitions of data of their quintessential quality, with profound consequences in the attitudes of their future users. If one assumes that data were given to and known by decision makers and actors, then they must have already developed some kind of models of the situation they are in. If so, those data need NOT be communicated to them, and, if communicated, the respective communications are redundant; they change neither their models not the situations the users are in. Within the mathematical theory of communications so defined, a datum, a factor in form, or a physical pattern of signals, if transmitted, is associated with a ZERO amount of information because the states of the informing entity and the entity informed were equal with regard to this pattern, and the entropy of the communication system remained unchanged (the amount of information statistically measures the difference).

As practiced in most organizations, data are captured not by direct users, but they are captured on behalf of many users. *Organizational* data are not immediately available, i.e., given to their direct users; hence, they must be communicated to those users, to whom they then appear as informative or as information derived from data. The use of the term "data" without referring to "whose data" leads to a pervasive impression that data are the main source of information. This is approximately what our students are currently taught, while, actually, such data are only secondary sources of information.

Thus, data are factual subsets of information that are meant as factors in form; they cannot be informative to those who know them, to whom they were given. The difference between data and information is as simple as what of a factual nature is already available, given, known, or assumed to be true by the user. The rest of the factors in form remain uncertain—of not yet established reliability.

HOW FACTORS IN FORM AFFECT OPERATIONS

Effectiveness, ethics, and/or efficiency of operations and strategic shifts depend on many factors including factors in form and their quality. Wang and Strong's [30] survey identified a plethora of 179 dimensions of data quality. At first, the multidimensional quality space appears chaotic. Can it be classified and ordered (see [15])? Only some quality aspects are intrinsic to factors, while all the others are situation specific, hence *contextual* use requirements. Analysis of strategic requirements calls for many additional answers:

1. Which of them affect operations **directly** or only **indirectly**?
2. Which are **necessary** or only **desirable**?
3. Which of the necessary are **primary** and which are **secondary**?
4. Which of the primary are **universally necessary** (categorical) or **situation-specific necessary**?
5. Which of them affect operations **qualitatively** or mainly **quantitatively**?
6. In what **order** should they be examined?
7. What is the extent of their impact—**materiality**, and how should it be measured?

Most current studies of information quality never ask these questions that cannot remain unanswered when shifts in business strategies occur.

Directly means that changes of use requirements directly affect the decision situation, the way decisions are implemented, and/or the results of operations. ***Indirectly*** means that such changes contribute to the state of quality of their respective higher-order factors (ultimately the direct ones). ***Necessary*** use requirements are mandatory. If any of them cannot be met, it precludes further examination of the

affected factor. Such a binary distinction is rarely made in current IQ studies, and the logical interdependency of the necessary use requirements is practically ignored. The necessary use requirements may be primary or secondary. ***Primary use requirements*** are those necessary use requirements that are determined by the nature of the situation, thus objectively independent of the decision maker. ***Secondary use requirements*** depend on the chief executive decision maker; they usually pertain to ethics and efficiency of operations.

Necessary requirements are of the highest importance and of the same ultimate consequences; if not met, the affected factor is not usable for operations. Some are always necessary; hence, the ***universally necessary*** are ***categorical***, while the remaining ones are ***other situation-specific necessary***. Only the universally necessary use requirements can be explicitly enumerated. Jointly meeting the necessary use requirements make a factor ***usable.*** Each factor should be tested first for its ***operational usability*** at some previously defined levels of needs and expectations. Changes of necessary and sufficient use requirements always QUALITATIVELY and QUANTITATIVELY change the decision situation. Asserting operational completeness of factors before one establishes their individual task-specific usability makes no sense but is frequently practiced in many studies of data quality.

Changes of quality aspects (subject to use requirements) subsequently require a partial redefinition of the decision situation (e.g., *adding or deleting column(s) or row(s)* from the decision-situation matrix) is a ***qualitative change***. Changes to states of gradable quality aspects affect ***mainly quantitatively*** the results of operations, the decision situations, and/or the way decisions are implemented. Mainly means here that gradable use requirements that quantitatively affect operations do not exceed their respective acceptable limits (e.g., *limits for driving under the influence*) or reach other critical states (e.g., *melting, evaporating,* or unexpected *freezing* in deep-water-well capping) that also may trigger qualitative changes, including explosions.

Among the universally necessary requirements, only **operational materiality** adequately measures the scope of a factor's impact on operations; otherwise, a comparative impact analysis is impossible. ***Operational materiality*** of an entity is measured by the difference in the measure of results, when operations are conducted with and without the entity. It is ***significant*** when it exceeds some threshold of significance that is determined by the policy in effect. In operations, ***significant operational materiality*** is not only necessary primarily and categorically (universally necessary), but also the fundamental, central, and most pervasive requirement related to use of all factors, including factors in form. In most financial cases, it can be interpreted as recommended by the Generally Accepted Accounting Principles (GAAP). Materiality reins supreme over all the other aspects of factors in form because (except for research of unknown phenomena), in most cases, from the perspective of practitioners, anything of INSIGNIFICANT operational materiality does not deserve much attention. **Materiality** is

- ***fundamental***—because it is the **only necessary, hence categorical use requirement** that provides each factor with a **sufficient reason** to be considered in operations.
- ***central—***because it is **indispensable** for all considerations about **effectiveness** and **efficiency** of operations; it **ranks** or orders all factors.
- the ***most pervasive*** use requirement—because it **determines the materiality of** the remaining necessary **quality requirements** of the same factor, it determines the materiality of its **necessary companion factors** in tasks, and, to a lesser degree, it affects the materiality of **indirect factors** that are related to a **direct factor.**

Thus, information items, including their respective intrinsic quality aspects and use requirements, can be partially (asymmetric, transitive) ordered by materiality. There is probably no other more compelling reason to teach MIS students any other concept in this domain than the significant operational materiality of factors in general and of data or information in particular, including their quality. The reality is just the

opposite. All authors of the known MIS textbooks ignore this subject. The only exception (Alter [1]) cared to mention it mockingly, writing that it is "*more elegant than practical.*" It illustrates once more how "*blind*" examiners of the metaphorical elephant (here, quality) miss the central focal point of all considerations and the most fruitful perspective possible.

Use requirements should be examined in an economical, not a haphazard, sequence. The necessary requirements may be ordered by their strength as prerequisites. The ***strength of a prerequisite use requirement*** is measured by the number of necessary use requirements that must be tested if that requirement is met (or not tested if it is not met). Difficulty of testing may again rank those of equal strength as prerequisites. Ordering of the necessary requirements can be determined by their pair-wise comparison with regard to a stated criterion. Indirect use requirements may be ordered by the level of their indirectness, which is measured by one plus the number of intermediaries between the examined indirect use requirements and the ultimately affected direct factors. Thus, indirect factors may be of the first, second, and subsequent orders. Hence, members of each subclass of use requirements can be ordered by their materiality and some other applicable criterion. Thus, all categories of use requirements satisfy the axiom of choice [2] of the theory of sets making use requirements *well-ordered sets*, at least in most cases.

The extent of the triggered changes may vary considerably. For instance,

1. the model of the situation, the way the decisions are made and implemented, and the results of operations according to the adopted measure may change them all (the largest extent);
2. the model remains unchanged; however, the changes affect the results of operations and the way decisions are implemented (the medium extent); or
3. the model and the way decisions are implemented remain unchanged; only the results of operations change quantitatively (the smallest extent).

Factors, to be operationally usable, actionable, and useful, must meet many necessary (primary and secondary) use requirements, as defined in [16].

SUMMARY

Quality of information is the aggregate of the entire experience of users at all the touch points related to use of information for operations and articulation of business strategy when information is a significant factor. In this study, factors in form entail primary information, actionably reliable data, secondary information, and other elements of replicable knowledge.

Shifts in business strategy affect the focus and scope of the aligned information-quality management systems. Quality assessment and assurance are changing dramatically from routine data that usually play familiar roles in contrast to the highly unreliable primary information that is acquired for strategic purposes by political, military, or business intelligence.

Actionable reliability of the gathered intelligence and the factual nature of data of significant materiality are the necessary prerequisites for the effectiveness of the supported strategy. This can be attained only by information-quality management with quality assurance of much higher rigor than that required for routine data of known roles. Two selected historical cases illustrate the possible chasm that may develop between the primary or raw information gathered by intelligence and the needed actionably reliable information and, similarly, the chasm between the data stored and the actual facts they purport to represent. Shifts in strategy require not only adequate alignment of information-quality management but also much higher standards of quality assurance.

This close relationship seems to elude most of the academic reviewers. They suggest separate papers about strategic alignment of information quality and linguistic semantics of the proposed terminology without noticing that here we deal with much stronger semantics—the natural semantics of operations. It considers how factors in form, whether information, data, or other elements of knowledge impact effectiveness, ethics, and efficiency of operations. The strength of the impact is measured by its materiality with regard to the purpose of operations—the main point of reference so emphasized by Einstein for all observations and assessments. This also illustrates the chasm that may separate the views of academicians and practitioners concerning strategic alignment of information quality.

Worse, no reviewer has tried to refute any of the presented propositions as contradicting or not fitting reality. All of the emphasis has been placed on scientific style, broader analysis of scholarly literature (to demonstrate currency), a rigorous analysis of the state of the art, improvement of the theoretical framework, and the "*deepest analysis*" of what is a "fact" to "*provide a stronger philosophical and foundational basis to the argumentation.*" Thus, the entire emphasis pertains to scholarly aspects without touching the essence of the issues even if likely presented in insufficiently elegant form.

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