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Information Quality: The Importance of Context and Trade-Offs

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Abstract

"Information quality" is arguably the most important information systems construct, and yet there exists no common definition of this construct, or set of recommendations for its appropriate usage and measurement. This paper explores the nature of information quality as a contextual, or fit-based, construct. Using this contingency approach we see that the definition of information quality is dependent on context, and instead of containing a clear maximum (or maxima) is rather comprised of tradeoffs. A call is made for restraint in uniform definition and measurement of information quality, acknowledging its appropriate use based on a specific construct-context fit.

1. Introduction

For a moment, consider figure 1 provided below and what message this image portrays. If one were to view the image on the left by itself, it would lead him/her to a very different conclusion than viewing the image on the right. Neither of these conclusions would be completely accurate, as it is clear that the image in the center provides the most accurate context of the scene captured by the image. As is the case in other situations, proper assessment of a situation or a proper decision can be only made if accurate information is provided, making information quality key predictor of later decision-making performance.

The importance of figure 1 is in the realization that context matters and that even in our academic research, we need to pay particular attention to its effects on information. This notion has been similarly raised by other researchers [8]. The remainder of this manuscript will address the importance of context on one of our core constructs – information quality. The manuscript further explains why this context also creates unprecedented challenges for information sharing after the initial decisions are made.

As an applied discipline, information systems (IS) research tends to focus on practical considerations, i.e., creation and usage of IS [2]. In this quest, rigorous research focuses on interactions between latent variables by: 1) developing good measures, and 2) accurately detecting relationships that actually exist. An item often overlooked in past IS research has been a specific focus on the constructs themselves [2, 9, 18]. While referent disciplines, such as Psychology, have created construct-based research, the IS community allowed definition of its constructs on a project-by-project basis. This creates a number of problems that impede progress as a community: 1) while it might be possible to identify an intellectual core, the actual *meaning* of the core constructs themselves is variable, 2) any given piece of research is less generalizable to other contexts, 3) and measurement items are mis-appropriated (or mis-specified) at an arguably high rate [13, 20, 22, 27]. Without proper global scale assessment, it is unclear as to what the boundary conditions are for the use of a particular constructs and whether there are context specific factors that affect the appropriateness of use [14, 17].

Figure 1. Information quality: Importance of context

In the following sections, we hope to address some of these issues for one of the most central IS constructs: information quality. As discussed by numerous authors (notably [5]), *quality* of information is desirable as an outcome of any information system, because it mediates downstream variables such as success, and influences feedback

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loop between IS usage and design. Further, if one views an IS with an *information* lens (such as [9] does), then the information itself is arguably the core IS construct, nested in a nomological network consisting of sociotechnical structures that support and use the information. Yet, shared agreement on the meaning of this construct continues to be very elusive. Arguably, the last thirty years of IS research and scholarship have provided the essential task of analyzing information quality by breaking it into its component parts, yet there seems to be little agreement on the proper compilation of items to describe the construct as a whole. If one agrees that there are parts that influence the whole, the question remains whether simple addition of parts creates a better whole or whether the relationship between these parts is more nuanced, filled with tradeoffs and contradictions.

In light of these questions, this paper synthesizes our knowledge about the construct using a fit-based approach. We believe that some of the "confusing" findings of past research may have been caused by inappropriate use of constructs in contexts for which these construct were not a good fit. An example of a finding that would support this view comes from Raghunathan [25] who notes that an increase in information quality improves decision quality if the user understands key contextual relationships between variables, but otherwise may actually *degrade* decision quality. Analysis necessarily precedes synthesis; therefore, we begin by exploring the definition of information and quality. Next we address a trade-off perspective of the construct that emphasizes the importance of context in operationalization and measurement.

2. Literature Review

2.1. Defining "Information"

English [7, p.19] follows a number of authors in defining information as "data in context," or data imbued with meaning. The other common view is provided by Valacich and Schneider [29], who define information as "data that has been formatted and/or organized in some way to be useful to people." But what does information look like? The answer is, of course, that information is an infinitely variable set of qualities that one might perceive in a given data set such that one is able to define patterns, infer a larger meaning (a gestalt), and that this pattern is shareable amongst individuals such that two different individuals might derive the same conclusion from the same given set of information. Admittedly, the aforementioned is an idealistic notion. Although we can collectively define information and understand what the term means, in practice, two given individuals will *always* formulate different notions of information content because they are processing the information into knowledge with an inherently *tacit* and *explicit* component unique to the infinitely varied processing capabilities of the receiver [23] making knowledge sharing both important and difficult to understand and study. These idiosyncrasies are precisely what makes identifying a common notion of information quality very challenging, because information-in-use is inherently subjective [24]. This subjective property of information is what makes information sharing very difficult, which can be directly attributable to the reasons why as many as 88% of data/information integration project fail [21]. To add to the complexity, let us now look at the definition of quality.

2.2. Defining "Quality"

Much the same as the term information, the term "quality" is in the eye of the beholder. As stated above, perhaps the best definition of "quality" is "fitness for a particular purpose." In other words, although one might be inherently able to visualize what this term means, when it comes to an objective definition, one must fall back on the adage "I'll know it when I see it." So, because the term quality is inherently *situational*, it adds an additional layer of complexity to that of information. English [7] makes the important point that a "quality" product is not one that is "best" in every category, but rather one that best meets overall expectations for an intended use (often determined *post hoc*—after purchase). Kahn and colleagues [15, p.185] further break the term quality into two components: 1) conforming to specifications, and 2) meeting/exceeding consumer expectations, which again adds another layer of complexity, especially for situations where sharing is expected and the parties may not inherently agree on their definitions of quality for a variety of possible reasons.

2.3. Defining "Information Quality"

When one combines the two nebulous terms, "information," and "quality," one is left with an ambiguous definition of "data imbued with context that expresses fitness for a particular purpose"—a definition that unfortunately may lead to absolutely contradictory operationalizations. English [7] argues that once information is stored, with the potential to retrieve it, quality is *not* fitness for purpose, but rather fitness for *all* purposes, including *likely* future purposes. In his estimation, information quality, then, is a mixture of inherent (correctness) and pragmatic (usefulness) qualities: clear data definitions, correct data values, and understandable presentation. He concludes by stating that in order to define information quality, one must identify its "customers," and for the purposes of this paper, we would substitute a more general term, "context," to describe a set of customers with a specific purpose, in a specific task setting. If information quality is viewed in this sense, then information sharing would be improved because data would be stored with future use in mind. The next section elaborates on the idea of viewing and defining information quality as a set of trade-offs rather than a construct composed of dimensions that necessarily and additively lead to greater quality.

3. Context, Dimensions and Trade-Offs

As previously mentioned, much existing research argues for the imperative of *high* information quality (except perhaps in deception research). Taken in context, many of these studies were arguably measuring one or more aspects of information quality; however, it remains to be seen whether or not it is desirable to maximize all aspects of information quality in any given setting. Further, it remains to be seen whether or not it is *possible* to maximize them all in a given setting. Lastly, it should be noted that one aspect of maximizing quality that cannot be overlooked is its cost as depicted in figure 2 and thus it should be desirable to maximize the quality of only those dimensions that are necessary for a particular context, rather than maximizing any and all dimensions at all cost regardless of true purpose.

Therefore, as some argue [4, 15, 16, 26], "quality" is a term that can be best understood in terms of fitness for a particular purpose. For this reason, it is possible that previous definitions of information quality have been mistaken in their analysis of quality as an *additive* composite, rather than as a concept of *fit*—where the fit between a situation, user type, and information type are required for that particular person-situation context. Indeed, this may be one reason why perceptual measures of user satisfaction are usually preferred to straight-out information quality measures, with the thought being that user satisfaction captures the difficult-to-describe "fitness" nature of the information quality latent variable. In the absence of a fit-based model of information quality, this downstream, reflective variable is arguably a better approximation of information quality than an additive, composite latent variable. So, to be useful, an information quality model should be adapted to consider components of information that are useful to a particular user in a particular situation. Unfortunately, this complicates the matter because the answer to "what is quality information" must always necessarily be "it depends..."

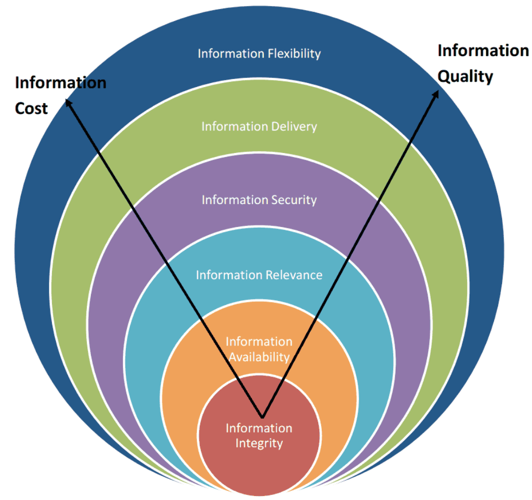

Figure 2. The cost of information quality

For example, in the context of decision-making, decision quality is related to the interaction between information, decision-maker, and environment [25]. In real-time dynamic environments, "decision quality" implies about a 70% level of certainty—in other words statistically-significantly different from a guess, but with considerable residual uncertainty. So, in this context, the quality variables of importance are *speed* and *accuracy*, but with the inherent understanding that the two components are held in tension with each other. One can make decisions very quickly using automatic processing [1] by choosing to prefer speed, with the inherent understanding that a slower but *more comprehensive* step-by-step approach to decision making based on sequential processing [28] will allow more information to be analyzed and will likely increase accuracy. So in this context, perhaps information quality exists as an inflexion point in the tradeoff between these two items. Adding more variables, such as cost, increases the importance of context. Because one may not minimize cost while maximizing speed and accuracy, then perhaps information quality in this context means minimizing cost while maximizing the effective tradeoff between speed and accuracy.

If the "quality" tradeoff exists between variables, then it also may exist within the same variable as it abstracts to different contexts. Numerous authors (starting with [12]) attest to the relevance of organizational hierarchy in driving the tradeoff between amount and relevance. The more information one is confronted with, the less relevant it may appear (also termed "information overload). However completeness of information is perhaps even more important when information is summarized and received at the top of the management pyramid because while this information is more focused and the fine granularity of information must be sacrificed, the correctness of this information is crucial. It also increases the importance of clarity/unambiguity, because multiple interpretations might now exist. Hence, the tradeoff is termed "flexible" information—information that can serve multiple purposes, but arranged in such a way that it can be reconfigurable. Likewise, another information quality dimension becomes important—that of feedback. If communication can be set up such that an individual can contact the individual who compiled the information, and ask more detailed questions, then "information quality" is increased. Again, one may pay to reduce the tradeoff between these other dimensions through increasing cost, but only if cost itself is not a separate information quality dimension. A conceptual view of these trade-offs is provided below in figure 3. A similar notion of trade-offs has been previously proposed by Fehrenbacher and Helfert [8].

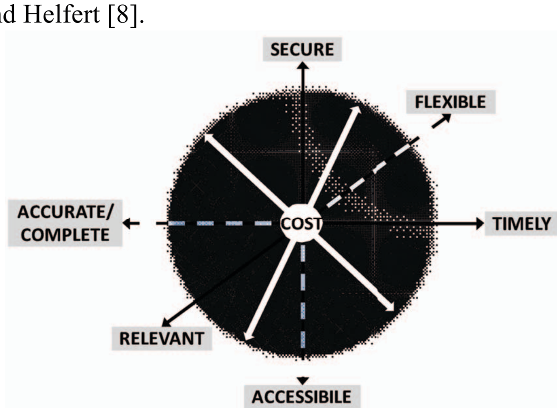

Figure 3. Information quality trade-offs

4. Discussion, Recommendations and Future Directions

One might ask whether talking about information quality is a meaningful discussion today, when new tools allow us to deal with "Big Data", characterized by large volume, velocity and variety. While this is true, we would argue that paying particular attention to information quality today is perhaps more important than ever. Figure 4 provided below displays the expected growth of information creation in the next decade, which is expected to continue its exponential growth rate, reaching approximately 40,000 exabytes by year 2020.

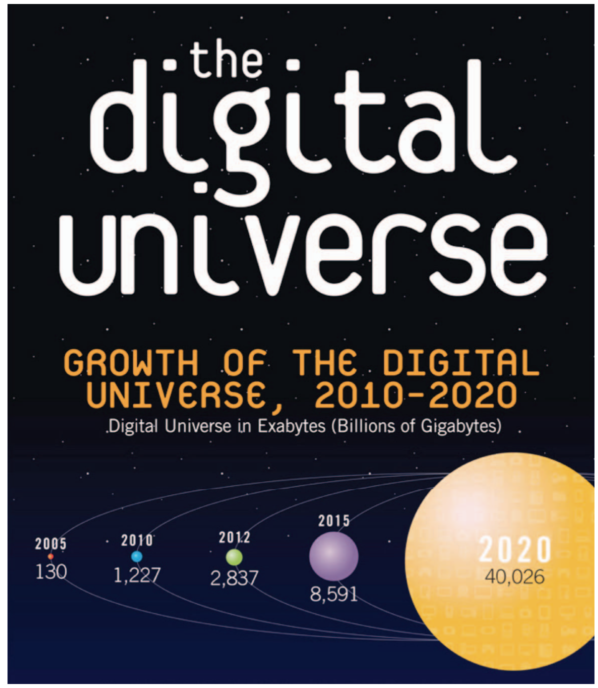

Figure 4. Projected information growth (adapted from EMC^2: Business and the Digital Universe)

As can be seen in figure 5 provided below, the real problem with this exponential growth of information lies in the fact that only a certain portion of this information will be useful while as much as 70% of this information will be noise, leading to potential information overload [11]. Additionally, it has been also argued that our ability to store information will lag behind our ability to create it [10]. With this in mind, we would argue that information quality may need to be perhaps considered differently for when data is first collected and for the "last mile" of information delivery, decision making and knowledge sharing. Due to advances in technology, it is possible to collect virtually anything and information quality in the early stages may be driven more by cost considerations than any other variables. At this time, perhaps the primary consideration is related to the inherent correctness as described by English [7]. However as we move through the process and deal with knowledge, it may be more important to talk about effective display of information for decision-making and knowledge-sharing because while technology is better equipped today than ever to deal with these vast amounts of data, human brains are still susceptible to information overload. Proper understanding of the trade-offs information quality affords may be the only way to keep information quality high while avoiding cognitive overload. At this stage we would find important what English [7] termed pragmatic or usefulness qualities.

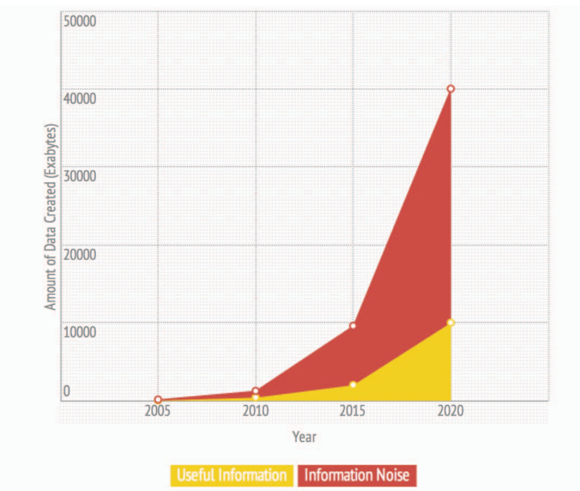

Figure 5. Useful information vs. information noise and its relationship to information overload

A model describing these drivers of information quality considerations is outlined in figure 6 below. Each of these stages can then be decomposed to show in further detail the particular trade-offs one should consider in an effort to keep "information quality" high. This may be particularly important as the needs of what can be considered high quality information change throughout the process of knowledge creation. At first, it may be crucial to identify key information to collect in order to be able to analyze the appropriate data, which is meaningful even in the era of big data, since data collection, storage and analysis cost money and collecting unnecessary information not only costs an organization more but also may prevent it from analyzing data that is actually important due to information overload.

In the later stages however, information quality will be particularly related to the way it is shown and shared as at this stage, the granularity of the information decreases but the importance of high quality of information increases for appropriate decision making performance. Quality at this point can be measured in terms of usefulness and completeness rather than pure correctness. If one were to consider figure 1 again, the correctness of the image in terms of light and exposure and saturation does not change, however the usefulness of the image for appropriate perception, decision making and information sharing changes as one views the full image rather than just a portion of it.

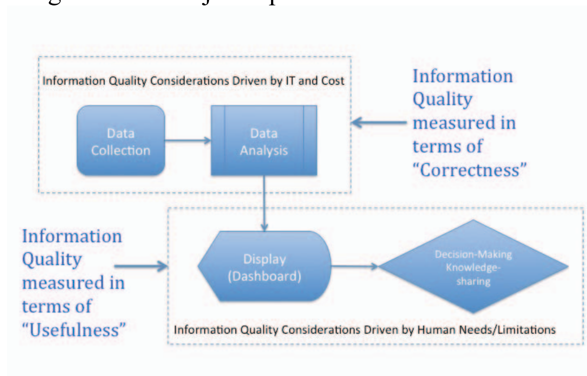

Figure 6. Drivers of information quality

Lastly, there is some support in past literature for a similar approach. Fox and colleagues note that "the variety of contexts where data appears makes generalization difficult" [8]. Levitin & Redman [19] note that some quality criteria naturally reinforce each other, but also that tradeoffs may exist between the items. If context matters, then one may have to consider such trade-offs and understand the complex nature of appropriate fit. Table 1. provided below shows the way in which information quality has been studied in the past. As can be seen from this table, there have been many different trade-offs studied and it is difficult to generalize based on this vast and varied body of literature. Looking at this table closer however, certain patterns begin to emerge and it is possible to start organizing these past findings based on the tradeoff dimensions similar to those described in Figure 3 and the stage in the knowledge creation process described in Figure 6. If one were to reorganize the past body of research into such categories, it would then become possible to argue for the boundary conditions at which particular dimensions lead to greater information quality within a specific context.

This paper thus calls for a re-evaluation of the construct of "information quality" as a contextual and fit-based construct. Furthermore, we believe that it would be more appropriate to evaluate information quality as a process rather than a static one-time measure; to better capture its essence as "information" changes from data to knowledge and passes through various different contexts. Considering the proliferation of definitions and measurement items created over the last 30 years this may be no small task; however, it is essential to the accrual of an academic tradition with respect to this, arguably most important and core IS construct. In the meantime, we recommend restraint in use of the very generic term "information quality" in favor of a more precise definition of what exact information quality trade-off dimension is required by a specific individual, in a specific context, acknowledging tradeoff inherent therein.

Table 1. Overview of past Information Quality research

Information "Quality" Dimension	Example*
Cost (Economical, Price, Efficiency, Practicality) - Cost equated with quality - More expensive decision process reduces marginal utility of stock purchase/sale	Snavely (1967), Ho & Michaely (1988), Naumann & Rolker (2000)
Accessible (Available, Dependable, Reliable, Format, Understandable, Comparable/ative, Usable/ease-of-use, Ease-of-remember/recall, Suitably presented, Ease-of-manipulation, Interpretability) - Information overload Perception may affect purchase behavior	Santhanam & Guimares (1995), Miller (1996), Wand & Wang (1996), Wang & Strong (1996), Naumann & Rolker (2000), Zhu & Gauch (2000), McKinney et al (2002), Boyee et al (2003), Nelson et al. (2005), Price & Shanks (2005), Price et al. (2008), Su et al (2009), Blanco (2010)
Timely (Fast, Urgent, Current, Quick, Continuously Updated, Volatility, up-to-date, Latency, Response time, Practicality) - Accuracy (experience may moderate) - Information may be better (triangulate) or worse (overload) - Increased burden on individual to manage *attention/focus*	Snavely (1967), Zmud et al (1990), DeLone & McLean (1992), Fox et al (1994), Ballou & Pazer (1995), Miller (1996), Wand & Wang (1996), Wang & Strong (1996), Santhanam & Guimares (1995), Ahituv et al (1998), Naumann & Rolker (2000), Zhu & Gauch (2000), McKinney et al (2002), Rieh (2002), Nelson et al. (2005), Price & Shanks (2005), Su et al (2009)
Flexible (Ad hoc, Combine-able, Compatible, Integration)	Santhanam & Guimares (1995), Miller (1996), Wand & Wang (1996), Nelson et al. (2005), Price & Shanks (2005), Price et al. (2008)
Complete (Complex, Objective, Wide-ranging,	Snavely (1967), DeLone & McLean (1992), Todd

Table 1. Overview of past Information Quality research (continued)

Raw, Unique, Sufficient/sufficiency, Scope, Detailed, Amount) - Timely (takes longer to search (unless redundant information is distributed, *shortening* search; experience may moderate) - Understandable (under conditions of time pressure) - Relevance (more complete may mean *less* relevant)	& Benbasaat (1992), Fox et al (1994), Miller (1996), Wand & Wang (1996), Wang & Strong (1996), Ahituv et al. (1998), Naumann & Rolker (2000), McKinney et al (2002), Nelson et al. (2005), Price & Shanks (2005), Su et al (2009)
Secure (Confidential, Sensitive)	Zmud et al (1990), Miller (1996), Wang & Strong (1996), Naumann & Rolker (2000), Price & Shanks (2005), Price et al. (2008)
Relevant (Precise, Narrow, Personalized, Applicable, Related, Simple, Selective, Subjective, Processed, Useful, Concise, Importance, Informative, Instrumental, Suitability of Presentation, Information-to-noise ratio, Cohesive, Non-redundant, Meaningful, Valuable/value-added, Appropriate amount) - Cost (most relevant items may be costly to obtain)	Snavely (1967), DeLone & McLean (1992), Miller (1996), Wand & Wang (1996), Wang & Strong (1996) Naumann & Rolker (2000), Zhu & Gauch (2000), McKinney et al (2002), Rieh (2002), Boyee et al (2003), Price & Shanks (2005), Price et al. (2008)
Accurate (Verifiable, Reliable, Correct, Free from Bias, Believable, Consistent, Authority/Reputation of Source, Integrity/Free from Defects/error,	Snavely (1967), DeLone & McLean (1992), Todd & Benbasaat (1992), Fox et al (1994), Ballou & Pazer (1995), Miller (1996), Wand & Wang (1996), Wang & Strong

Objectivity, (Correct) Content) - Effort/accuracy - Effort/amount (not shown) - Timely - Relevant (error checking may require redundant information) - Generally improves over time to a point, then may deteriorate (real-time vs. long-term DM); Authority may not be related to web search effectiveness	(1996), Raghunathan (1999), Naumann & Rolker (2000), Zhu & Gauch (2000), McKinney et al (2002), Rieh (2002), Boyee et al (2003), Nelson et al. (2005), Price & Shanks (2005), Su et al (2009)
Clear/unambiguous (Clarity, Readability, Interpretability, Understandable, Coherent) - "If, information is either unintelligible or meaningless . . . all its other qualities are irrelevant." Boyee et al (2002)	Snavely (1967), DeLone & McLean (1992), Miller (1996), Wand & Wang (1996), Wang & Strong (1996), Naumann & Rolker (2000), McKinney et al (2002), Boyee et al (2003), Price & Shanks (2005)
Popularity	Zhu & Gauch (2000)
Suitably presented, format (Concise representation, Flexibility of presentation)	Miller (1996), Wand & Wang (1996), Naumann & Rolker (2000), Price & Shanks (2005), Price et al. (2008)
Reputation (of source), validity, trustworthy/authoritative, system quality (verifiable/auditable, documentation, Feedback/Access to Metadata)	Zmud et al (1990), Miller (1996) Wang & Strong (1996), Naumann & Rolker (2000), Rieh (2002), Nelson et al. (2005), Price & Shanks (2005)

* Note: References for citations in Table 1 not provided as they are used only for reference and not used for the purposes of any main argument

5. Limitations

We would like to acknowledge that even though every effort was made to locate all relevant literature dealing with information quality, we understand that we have not addressed research addressing information quality in areas outside of the core information systems literature.

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