Conceptualizing Information Quality: A Review of Information Quality Frameworks from the Last Ten Years

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Abstract

This paper analyzes seven conceptual frameworks on information quality along six criteria in two dimensions in order to identify common elements, differences, and missing components of such frameworks. The frameworks are evaluated according to analytic (or scientific) criteria and pragmatic (or operational) criteria. The analytic criteria are based on academic standards and require clear definitions of the terms used in a framework, a positioning of the framework within existing literature, and a consistent and systematic structure. The pragmatic dimension consists of criteria which make the framework applicable, namely conciseness (i.e., if the framework is memorable), whether examples are provided to illustrate the framework, and the inclusion of tools that are based on the framework. The review of the frameworks showed that information quality frameworks are either strong in their analytic dimension or in their pragmatic dimension, but rarely strong on both dimensions at the same time. The evaluation also revealed that the IQ frameworks are often domain-specific (i.e., for a specific application such as data warehouses or corporate communications), and that they rarely analyze interdependencies between the information quality criteria that are included in a framework. The paper concludes by outlining five future directions for information quality frameworks: first, the quest for more generic models. Second, the development of IQ frameworks that show interdependencies between different quality criteria. Third, the inclusion of problem areas and indicators into these frameworks (thus frameworks that go beyond simple quality criteria lists). Fourth, the development of tools which are based on an information quality framework. And lastly, the development of frameworks that are at the same time theoretical and practical.

Keywords*: information quality, framework, quality criteria, quality dimensions, information quality research*

1. Introduction

Frameworks of information quality abound in management and information technology literature. In our review of information quality literature from the last ten years, we have found twenty information quality frameworks that define and categorize quality criteria for information in various application contexts (see Table 1).

Author & Year of Publication	Application Context
1. Horn 1989	Hypertext Instruction Manuals
2. Augustin & Reminger 1990	Management Information Systems
3. Russ-Mohl 1994	Newspapers
4. Lesca & Lesca 1995	Corporate Communications
5. Morris, Meed & Svensen 1996	Management
6. Redmann 1996	Data Bases
7. Miller 1996	Information Systems
8. Wang & Strong 1996	Data Bases
9. Davenport 1997	Information Management
10. Eppler 1997	Corporate Communications
11. Ballou, Wang, Pazer & Tayi 1998	Data Warehouses
12. Kahn & Strong 1998	Information Systems
13. Harris & Flemming 1998	Knowledge Management
14. Königer & Reithmeyer 1998	Information Science
15. Moody & Shanks 1998	Data Models
16. Teflian 1999	Marketing
17. Rittberger 1999	Information Service Providers
18. English 1999	Data Bases
19. Alexander & Tate 1999	Web Pages
20. Eppler 1999	Multimedia

Table 1: Information Quality Frameworks from 1989 to 1999

Besides these twenty frameworks, we have found a large number of simple information quality criteria lists from such domains *as medical data management* or *medical publication standards*, *accounting* and *auditing* information quality, *Internet publication* quality etc. These lists, however, were just that: simple listings of criteria without conceptual insights. They are not frameworks in the sense that they would provide systematic orientation or problem solving potential like the twenty frameworks taken from academic publications above.

Goals of an Information Quality Framework

An information quality framework, in our view, should achieve four goals. First, it should provide a systematic and concise set of criteria according to which information can be *evaluated*. Second, it should provide a scheme to analyze and solve information quality *problems*. Third, it should provide the basis for information quality *measurement* and proactive *management*.

Fourth, it should provide the research community with a conceptual map that can be used to structure a variety of approaches, theories, and information quality related phenomena.

This understanding of a framework as a theory-building and practice-oriented tool is directly derived from Porter's conception of theory development as a choice for either limited models or comprehensive frameworks. Porter views frameworks as a legitimate form of research that can be validated through multiple case studies. He describes their aim as follows:

"Frameworks identify the relevant variables and the questions which the user must answer in order to develop conclusions tailored to a particular industry and company [...]. Frameworks seek to help the analyst to better think through the problem by understanding the firm and its environment and defining and selecting among strategic alternatives available."[1]

In order to better understand whether the above information quality publications can achieve this facilitating function of a framework, we use six criteria to evaluate selected frameworks from the above list. By doing this, we hope to learn more about the design of such frameworks for the information quality context and whether one domain can provide insights for another application domain.

Evaluated Frameworks

From the twenty information quality frameworks above, we have evaluated seven more closely in order to learn more about the characteristics of information quality frameworks and their potential to improve the understanding of information quality and resolve information quality problems.

The seven frameworks that are evaluated in this paper were chosen because they represent elaborated concepts and reflect the diverse field of information quality research in terms of *geographic origin* and *application context*. The authors of these frameworks come from France, Germany, USA, and England. Their research contexts range from data base application to newspapers (see Table 2).

Author & Year of Publication	Country of Origin
1. Lesca & Lesca 1995	France
2. Redman 1996	USA
3. Wang & Strong 1996	USA
4. Russ-Mohl 1998	Germany
5. Königer & Reithmeyer 1998	Germany
6. English 1999	England
7. Alexander & Tate 1999	USA

Table 2: Evaluated information quality frameworks

[1] Porter (1991), p. 955

Evaluation Criteria

The frameworks are evaluated according to *analytic* (or scientific) criteria and *pragmatic* (or operational) criteria. The analytic criteria are based on academic standards and require clear *definitions* of the terms used in a framework, a *positioning* of the framework within existing literature, and a *consistent* and systematic structure. The pragmatic dimension consists of criteria which make the framework applicable, namely *conciseness* (i.e., if the framework is memorable), whether *examples* are provided to illustrate the framework, and the inclusion of *tools* that are based on the framework. As Huang, Lee, and Wang note in their analysis of information quality frameworks, the choice of evaluation criteria can either be based on intuitive understanding, industrial experience, literature review, or consumer interviews. They also conclude that there is no general agreement on information quality dimensions.[2] For meta-criteria such as the one used in this paper, the same holds true. They have been chosen based on existing literature (e.g., articles on scholarly writing and academic journal review policies), common sense and interviews with practitioners. The following table outlines the key questions behind every meta-criteria (i.e., the criteria used to evaluate criteria-sets of information quality frameworks).

Meta-Criteria	Evaluation Questions
	Are all individual information quality criteria clearly defined and explained? Are all the dimensions to which the individual criteria are grouped (if existing) defined and explained?
	Is the context of the framework's application (and its limits) clear? Is the framework positioned within existing literature?
	Are the individual criteria mutually exclusive and collectively exhaustive? Is the framework overall divided into systematic dimensions that are also mutually exclusive and collectively exhaustive? Is it clear why a group of criteria belongs to the same dimension?
	Is the framework concise in the sense that it can be easily remembered? Are there (as a minimal rule of thumb) less than seven dimensions and less than seven criteria per dimension?
	Are specific and illustrative examples given to explain the various criteria (e.g., case studies)?
	Is the framework accompanied by a tool that can be used to put it into practice, such as a questionnaire, a software application, or a step-by-step implementation guide or methodology?

Table 3: Meta-criteria for the evaluation of information quality frameworks

Having outlined the goal and methodology of this paper, we can now turn to the actual evaluation of the seven frameworks with the six meta-criteria in the two (analytic and practical) dimensions.

[2] Huang, Lee, Wang (1999), pp.17-17

2. Seven Exemplary Information Quality Frameworks

Before we briefly discuss the seven information quality frameworks and their characteristics according to the six meta-criteria presented in part one of this paper, we start by discussing the most common definitions of information quality that can be found in information quality frameworks. We do this, since the type of definition that a framework uses typically affects the criteria which are included in such a framework.

Information Quality Definitions

In the review of existing literature on information quality, we have found seven different approaches to defining information quality.

1. Information quality can be defined as information that is *fit for use* by information consumers.[3]
2. Information quality is the characteristic of information to meet or exceed customer *expectations*.[4]
3. Quality information is information that meets *specifications* or *requirements*.[5]
4. Information quality is the characteristic of information to be of *high value* to its users.[6]
5. "The degree to which information has *content, form, and time characteristics* which give it *value* to specific end users." [7]
6. "Quality of information can be defined as a *difference* between the required information determined by a goal and the obtained information. In an ideal situation there will be no difference between the required and obtained information. A qualitative measure for information quality is expressed by the smaller the difference the greater the quality of information."[8]
7. Information quality is the characteristic of information to meet the *functional*, *technical*, *cognitive*, and *aesthetic* requirements of information *producers*, *administrators*, *consumers*, and *experts*.[9]

The most commonly used definitions are those ranked one through four. The seven frameworks evaluated in this paper typically use combinations of these four definitions.

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[3] Huang, Lee, Wang (1999), p. 43

[4] Kahn, Strong (1998)

[5] Kahn, Strong (1998)

[6] Lesca, Lesca (1995)

[7] Brien (1991), p. G-7

[8] Gerkes (1997)

[9] Eppler (1999)

Common Elements of the Frameworks

With the exception of the framework by Lesca and Lesca, all seven frameworks include a *time dimension* in their criteria set. Some frameworks refer to it as timeliness, stressing the rapid delivery process, while others stress the quality aspect of the information of being current or up-to-date (for which the timely delivery is a necessary but not sufficient prerequisite).

Five out of the seven frameworks rate *accessibility* or obtainability as an information quality criteria. Neither Russ-Mohl in the newspaper context, nor Alexander and Tate in the Web context give this important criteria any weight, which seems questionable, since both, newspapers and Web-sites, depend on a rapid and stable distribution channel in order to be of value to users.

Four out of the seven frameworks use *objectivity* as an information quality criteria. While most frameworks refer to it as an unbiased representation of reality, this criteria seems to be one of the most difficult ones in terms of clear definition.

Five out of the seven frameworks use the vague term *relevancy* as an information quality criteria. Definitions range from 'contextual impact' to synonyms such as pertinence to the end-user.

Accuracy is only seen as a central information quality criteria in three out of the seven frameworks. This is surprising since a great part of information quality literature with a background in information technology views this criteria as a central notion in the concept of information quality.[10] However, four of the seven frameworks use the closely related terms *precision* or preciseness as information quality criteria.

Consistency is only stated as an explicit information quality criteria in three of the frameworks. It refers to the systematic, non-contradicting, format and content of information.

Completeness is seen as a crucial information quality factor in four of the seven frameworks. It is viewed as a the characteristic of a set of information to represent reality with all required descriptive elements.

General Features of the Seven Frameworks

Besides the individual criteria used in the frameworks, one can also compare the general features of information quality frameworks. In doing so, we have found five distinct patterns in the evaluation of the seven frameworks. Below, we discuss these five insights into the nature of information quality frameworks.

1. As the overall evaluation of the seven frameworks in appendix 1 shows, only three out of the seven frameworks are generic, while four contain criteria that are very specific to a certain application context. This is representative of the whole of information quality frameworks, where we have found the majority of frameworks to be context-specific rather than generic and widely applicable.

[10] Wang, Strong (1996)

2. The seven frameworks are also typical information quality frameworks in the sense that they do not explicitly deal with trade-offs between individual information quality criteria (as, for example, in Ballou and Pazer, 1987). Typical trade-offs that probably exist between information quality criteria are:

- The trade-off between security and accessibility (for this issue see also Huang, Lee, Wang, 1999, pp. 50-52): the more secure an information system is, the less convenient is its access.
- The trade-off between currency and accuracy: the more current a piece of information has to be, the less time is available to check on its accuracy.
- The same trade-off holds for the criteria of correctness or reliability and timeliness: the faster information has to be delivered to the end-user, the less time is available to check its reliability or correctness.
- The trade-off between right amount of information (or scope) and comprehensibility: more detailed information can prevent a fast comprehension, because it becomes difficult "to see the big picture."
- The trade-off between conciseness and right amount (scope) of information: the more detail that is provided, the less concise a piece of information or document is going to be.

3. With the exception of the framework by Wang and Strong (see also Strong, Lee, and Wang, 1997, for this point), the seven frameworks often fall short in including problem categories and specific indicators (i.e., means of measurement) into the actual framework. Most frameworks only provide limited assistance to resolve information quality problems with the help of a frame of analysis, which a framework could and should provide. This is closely related to the fourth point revealed by our analysis, namely the lack of adequate tools.

4. Most of the frameworks evaluated in this paper lack supporting tools that put the framework into practice, except for English (1999) and again Wang and Strong (1996) which provide elaborate tools to go with their framework. As far as tools are concerned, most frameworks only convert the criteria into questionnaires that specify various aspects of the criteria.

5. The evaluation matrix in appendix one also illustrates that only the Wang and Strong (1996) framework offers both a solid foundation in existing literature and practical applications. It is the only framework in the series of seven that strikes a balance between theoretical consistency and practical applicability.

From these findings, we can derive future research needs in the area of information quality frameworks. We briefly outline these new directions in the conclusion.

3. Conclusion

The review of selected examples of information quality frameworks showed that they are often strong in their analytic dimension with thorough definitions and an extensive recapitulation of prior literature (and a systematic structure), or –alternatively- in their pragmatic dimension –

offering concise criteria sets, many examples, and facilitating tools-, but rarely strong on both dimensions at the same time. The evaluation also revealed that the IQ frameworks are often domain-specific (i.e., for a specific application such as data warehouses or corporate communications), and that they rarely analyze interdependencies between information quality criteria. From these insights, we have derived five future directions for information quality frameworks: the quest for more generic models, the development of IQ frameworks that show interdependencies between different quality criteria, the inclusion of problem areas and indicators into these frameworks, the development of tools which are based on an information quality framework, and the development of frameworks that are at the same time theoretical and practical. If progress is made in these areas, then Kurt Lewin's saying will be right that there is nothing so practical as a good theory.

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Appendix 1: Comparison of the seven frameworks

Models: **Criteria:**							
	All criteria are defined.	All criteria are defined.	All criteria are defined.	Definitions of certain criteria are fuzzy (i.e. objectivity, reduction of complexity).	All criteria and dimensions are defined.	All criteria are extensively defined.	All criteria are defined.
	Positioned within internal communi-cations for target group: students / managers	Positioned as a generic approach to information quality within the context of unstructured information	Framework is positioned within usability and web design literature.	Framework is positioned within existing literature on quality in the media.	Clearly positioned within existing information quality literature in the information technology context.	A focus on data quality (and data warehouses) from a TQM perspective.	Positioned within database literature
	IQ dimensions are process and product perspective. No contradictions.	IQ- dimensions on the information product level only. No direct contradictions.	No dimensions are given just pure criteria list.	Not all criteria are operationalized in the framework.	Overall concise. Some criteria are quite similar such as interpretability and ease-of-understanding.	Not very consistent since different frameworks are used, not one consistent model.	Model is not always represented consistently.
	Many short cases are provided	No cases or extended examples are provided.	Many examples are provided.	Some examples are provided.	Many examples are provided.	Short illustrative examples are provided.	Many examples are provided.
	9 criteria 2 in dimensions	18 criteria in 6 dimensions	6 criteria, no dimensions	7 criteria, no dimensions	16 criteria in 4 dimensions	15 criteria in two dimensions	27 criteria in 9 dimensions
	Simple checklists and matrices are provided as conceptual tools.	One simple checklist is provided.	Checklists are provided.	No tools are provided.	A comprehensive tool (questionnaire with software support) provided.	Extensive survey of available tools provided. Many checklists included.	Abstract step-by-step methods are provided.
Conclusion	Generic, practical	Generic, theoretical	Specific, practical	Specific, theoretical	Generic, balanced	Specific, practical	Specific, theoretical

Appendix 2: The Evaluated Frameworks

Lesca / Lesca (1995)

Information as product	Information as process
• usefulness	• trustworthiness
• comprehensibility	• accessibility
• relevancy	• objectivity
• completeness	• credibility
• adequate representation	• interactivity (feedback)
• coherence	
• clarity	

Königer / Reithmayer: (1998)

Dimension	Criteria
1. Intrinsic Quality	Preciseness, Objectivity, Trustworthiness
2. Access Quality	Accessibility, Security
3. Contextual Quality	Relevance, Added value, Timeliness, Information content
4. Quality of Presentation	Interpretability, Understandability, Conciseness, Consistency
5. Quality of the Meta Information	Existence, Appropriateness
6. Quality of Structuring	Existence, Appropriateness, Understandability

Alexander / Tate (1999)

Criteria	Explanation
1. Authority	validated information, the institution behind the information is visible
2. Accuracy	reliable, free of errors
3. Objectivity	information is presented without personal biases
4. Currency	updated content
5. Target group orientation	clearly signaled target audience
6. Interaction & navigation design	Intuitive understanding of elements and their functions

Russ-Mohl (1994)

Criteria	Examples
Objectivity	Interests of author are revealed
Comprehensibility	Abbreviations are explained
Relevance	Geographic, social, time-based closeness to reader's interest
Currency	Fast, but validated information
Reduction of Complexity	Background reports
Transparency / Reflexivity	• Clear editorial guidelines (Mission) corrigenda • Reports about the media industry
Interactivity	• Strict separation of promotional and editorial content • A neutral newspaper "referee" • Participation possibilities for readers (Forum, Internet, etc.)

Wang, Strong (1996)

Category	Dimension
Intrinsic IQ	Accuracy, Objectivity, Believability, Reputation
Accessibility IQ	Accessibility, Security
Contextual IQ	Relevancy, Value-Added, Timeliness, Completeness, Amount of Information
Representational IQ	Interpretability, Ease of Understanding, Concise Representation, Consistent Representation

Redman (1996)

Perspective	Dimension	Criteria
	Content	relevance, obtainability, clarity of definition
	Scope	Comprehensiveness, essentialness
	Level of Detail	Attribute granularity, precision of domains
	Composition	Naturalness, identifiability, homogeneity, minimum unnecessary redundancy
	View Consistency	Semantic consistency, structural consistency
	Reaction to Change	Robustness, flexibility
Values		Accuracy, completeness, consistency, currency / cycle time
		Appropriateness, interpretability, format precision, format flexibility, ability to represent null values, efficient use of storage
	Physical Instances	representation consistency

English (1999)

Dimension	Criteria
Inherent Information Quality	• Definition conformance • Completeness (of values) • Validity or business rule conformance • Accuracy to surrogate source • Accuracy (to reality) • Precision • Nonduplication • Equivalence of redundant or distributed data • Concurrency of redundant or distributed data • Accessibility
Pragmatic Information Quality	• Timeliness • Contextual clarity • Derivation integrity • Usability • Rightness (or fact completeness)