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A Conceptual Framework for Investigating Information Quality in Information Systems

Abstract:

User-studies driven investigations into systems based Information Quality (IQ) lack a consistent framework or model by which researchers can conceptualise the context of their study and identify the important elements and IQ dimensions to be examined and empirically tested.

Presented is the Combined Conceptual Life Cycle (CC/LC) model of IQ, a framework which enables researchers to develop a more accurate set of protocols through which to examine user/information interaction and perceptions of IQ.

Introduction

Information Quality (IQ) is a complex, multi-dimensional construct[1], the understanding of which is made all the more challenging when investigated within the context of systems based human Information Retrieval (IR), also recognised as involving multi-dimensional constructs[2].

This chapter explores the previous decade of research into systems-driven IQ to firstly establish any common elements regarding perceptions of information quality. It then proposes a conceptual framework by which researchers can develop context specific investigations into IQ as a user-perception driven phenomenon.

Discussed first is the broad concept of IQ, followed by a review of some of the seminal ideas and concepts associated with systems IQ. Specifically, the review examines those frameworks which sought to conceptualise the context of IQ characteristics, or "dimensions" in an effort to understand how users might engage their cognitive perceptions of IQ in the process of systems based information production and retrieval. The proposed CC/LC model of IQ is then discussed as a robust framework with which to examine systems IQ.

What is "Information Quality"?

Defining IQ: *"Fit-for-Use/Purpose"*

IQ is considered to be a multi-dimensional concept, in that multiple factors determine its state, existence and application. A somewhat general consensus has been reached in relation to a definition for IQ, sometimes used synonymously with Data Quality (DQ), as being information/data that is "fit-for-use" (also "fit-for purpose")[3].

Importantly, the "fit-for-use/purpose" paradigm, while still remaining ambiguous in relation to defining what IQ actually constitutes, is useful in that it implies IQ is context driven[4]. The great value in assigning a context to IQ is that it:

1.) Enables researchers to conceptualise the processes involved in any user/information interaction processes[5]; *which then*

2.) Facilitates the process of associating characteristics (called "dimensions") with the information, which can be used as value-judgment criteria[6]; *and*

3.) Helps researchers to better understand what criteria users may employ in their value-judgements of information[7].

The "fit-for-use" paradigm has been embraced by researchers for a number of reasons. Firstly, it facilitates the notion that IQ is *relative*, as information considered appropriate for one use may not possess sufficient attributes for another use[8]. Secondly, it puts into common language the *action* of information quality while still remaining enigmatic and relative like the concept it is used to define. More importantly though, it gives information quality an investigative *context* [9]. That is; it suggests that information quality cannot be defined and assessed outside of the reason for which it exists.

The problem with defining IQ in such non-specific terms is that researchers are still no closer to actually defining what a "quality" piece of information is, or what criteria can be used to quantify or measure it. In addition, within the context of information retrieval (IR), that which represents a quality piece of information is highly reliant on the perceptions of the retriever of that information[10]. The reality is, users of information are constantly making choices regarding its quality as they interact with the systems they use.

Frameworks & Models of IQ: *A Literature Review*

For the current paper, twenty one IQ frameworks[11] were examined from the previous decade of IS research. While varied in their approach and application, the frameworks share a number of definitive characteristics regarding their classifications and descriptions of the dimensions of information quality.

The frameworks examined were found to fall into four main types of models:

1.) Conceptual IQ identification models;
- CIQF - Categorical Information Quality Framework[12];
- SDQF - Semiotic Data Quality Framework[13];
- Conceptual Framework for measuring IS Quality[14];
- Mapping IQ into the PSP/IQ (becomes AIMQ)[15];
- IQM - Information Quality Measurement Methodology [16];
- IQ as a Life-Cycle[17].

2.) Frameworks that push existing models in order to apply them to a Web environment
- Extension of IQF into Web environments information contexts[18];
- Detection of IQ problems by users on the WWW[19].

3.) Development of IQ conceptual models into machine readable metrics
- Quality metrics for information retrieval on the World Wide Web[20];
- Classification of IQ Metadata Criteria[21];
- Using IPMAP to create machine readable (quality related) metadata about data[22];
- Quality metrics used to create Wikipedia IQ evaluation tool[23].

4.) Practical application of IQ guidelines to build user-resources and "how to.." frameworks for searchers of information – specifically user/searchers on the World Wide Web.

- CARS Checklist for Information Quality[24];
- (Web) Evaluation Criteria[25];
- Web Wisdom[26].

The models discussed in the current paper relate to those which sought to conceptualise IQ into general categories, seen as applicable to multiple systems contexts of IQ.

Conceptualising IQ

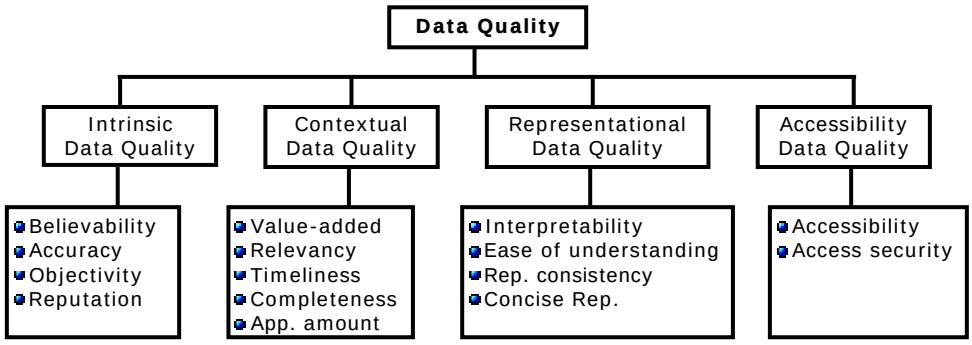
The valuable paradigm of contextual IQ postulated by Wang & Strong[27] allowed the authors to separate user/information interaction into two distinct contexts; (1) information production; and (2) information use. The further conceptualisation of IQ into categories associated with production or use proved to be a valuable methodology for identifying the ultimate dimensions proposed to be applied by users in their process of information interaction.

Wang & Strong built a contextually driven conceptual framework that categorised characteristics, which the authors' called "dimensions", into four contexts (or types) of information;

1.) Intrinsic IQ;
2.) Contextual IQ;
3.) Representational IQ;
4.) Accessibility IQ.

In the context of these four categories, fifteen different dimensions of IQ were identified. These are illustrated in figure 1. Wang & Strong's framework clearly demonstrates that the process of determining categories, or more broadly described, "conceptual contexts" for IQ, enables researchers to begin putting that which is, conceptually speaking, relatively intangible, into tangible descriptions which can be explored in concrete terms.

Figure 1. Wang & Strong's (1996) Categorised Model of IQ/DQ



Semiotic IQ

Shanks & Corbitt[28] conceptualised IQ in relation to cultural meanings; that is; how IQ could be understood in terms of the quality related meanings imposed on it as a socially created construct. Investigated from this more philosophically driven approach, the authors built IQ into a semiotic framework comprised of four levels:

1.) Syntactic: concerned with the physical/empirical structure of information
2.) Semantic: concerned with the wholeness of information
3.) Pragmatic: concerned with usage of information

4.) Social: concerned with the socially driven meanings of information.

At a theoretical level, the semiotic framework recognises its own constructivist view-point, that information itself is symbolic, and the framework acknowledges the building of imposed constructs in order to meaningfully classify the various characteristics of information quality. By beginning at a conceptual level, researchers are able to contextualise an investigation of the more abstract or esoteric characteristics of "quality" as a phenomenon. should be noted that subsequent semiotic approaches removed the "social" construct[29] of the 1999 model. The current author contends however, that this social construction of information quality remains an important concept in the context of IR driven IQ research.

IQ as a Life-Cycle

Liu & Chi's "Evolutional Data Quality" framework[30], built largely on a foundation of Wang & Strong's four category IQ model, conceptualises the process of user/information interaction into a *cycle* of four user/information interactive points:

1.) Information/Data Organisation;
2.) Information/Data Presentation;
3.) Information/Data Application;
4.) Information/Data Collection.

Illustrated in figure 2, Liu & Chi's information life-cycle, as a concept, was not new to information systems research[31]. It did, however, represent one of the first times the life-cycle was appropriated to help determine a context for the identification of specific IQ dimensions. The evolutional data quality model proposes that the stages of the life-cycle represent user/data interaction stages that evolve by building on one another. The model conceptualises the four named stages of user/information *interaction* into a cycle that incorporates the separation of IQ into (1) information/data *production*; and (2) information/data *use* contexts.

Figure 2. Liu & Chi's Evolutional Data Quality model (2002)

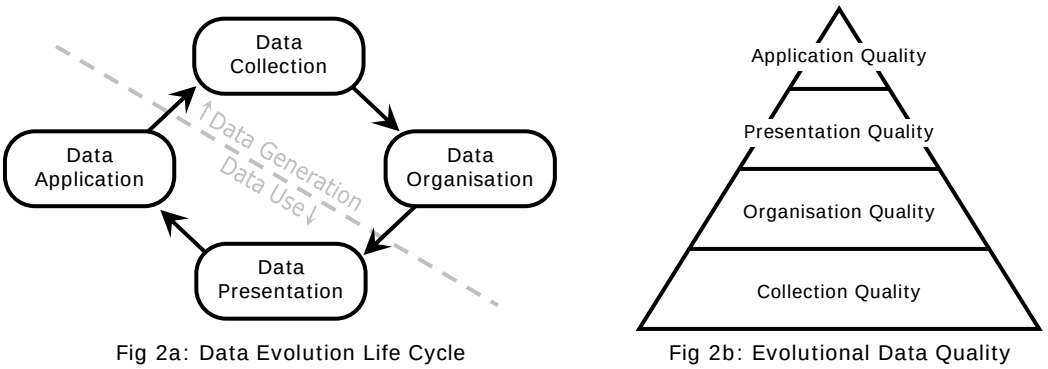


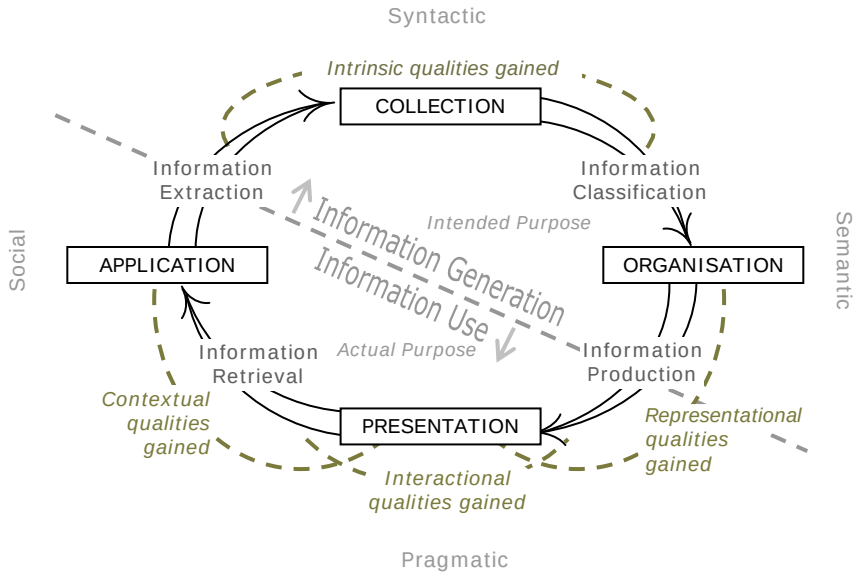
Fig 2a: Data Evolution Life Cycle

Fig 2b: Evolutional Data Quality

This paper seeks to develop further Liu & Chi's life-cycle conceptualisation of IQ by looking for synergies between the various conceptual models presented thus far, and placing them into a more detailed model which contextualises information interaction into this four-stage life-cycle. The revised model is presented in Figure 3 as a *Combined Conceptual/Life-Cycle (CC/LC) Model of IQ*. The CC/LC recognises that the various frameworks, although conceptualised using different language, are in fact, naming similar constructs. For example, Liu & Chi's data organisation quality is similar to Shanks & Corbitt's semiotic quality construct, with both

organisation and semiotic quality being similar to Wang & Strong's representational IQ.

Figure 3. Combined Conceptual/Life-Cycle Model of IQ



The value of conceptualising IQ into categories is that it allows researchers to then name more specific IQ characteristics (called "dimensions") proposed to be employed by users in their value judgments of the information they encounter.

A Consolidated Framework for Investigating IQ in Information Systems

IQ as a life-cycle concept

The combined conceptual/life-cycle (CC/LC) model of IQ sees the classification of information purpose (called "generation") and user's retrieval purpose (called "information use") as useful to any investigation into IQ because it puts into a context, the reason a user should interact with specific information. The model therefore firstly assumes that the common characteristics, or dimensions, of IQ engaged by users, and their level of critical importance to users' value judgements, will vary depending on whether a researcher is examining data quality perceptions from an information production, or information retrieval perspective.

The CC/LC model of IQ demonstrates a level of synergy between the conceptual models previously discussed, but also superimposes a set of user/information "actions" that take place dependent on the stage of life-cycle information interaction. These actions are representative of typical user/information interactions that take place during the IQ life-cycle, and include;

1.) Information classification[32]
2.) Information production[33]
3.) Information retrieval[34] *and*
4.) Information extraction[35].

It is important to note that the terminologies used are not exhaustive, but merely represent typical user/information interactions in a continuous process conceptualised in the literature as the information life-cycle. Information *collection*, for example, includes such actions as the

gathering, grouping and sorting of data, the latter of which could also be regarded as an action of information *classification*. The IQ life-cycle then, represents a continuum of user/information interaction, and understanding these interactions helps to identify the types of demands, and related IQ value judgements, users might make of the information they encounter.

Figure 3 presented the CC/LC model of IQ and where in this life-cycle the four broad level categories of IQ named by Wang & Strong; and Wang[36] are engaged by information users in the process of their IQ value judgements. The over-arching assumption of the CC/LC model is that IQ dimension importance and the value-judgments made in relation to them is heavily dependant on where in the life-cycle user/information interaction takes place. This is consistent with Wang & Strong's contention that IQ, as a construct and a value, is essentially contextually driven.

This contextual approach to investigating user perceptions of IQ is mirrored in virtually all twenty one IQ frameworks examined in the writing of this chapter. Authors' were found to firstly contextualise their investigation into (1) broad categories; (2) assessment classes/types; or (3) criteria/contexts. The naming of specific IQ dimensions, whether the studies are theoretically or user-data driven, are then described in the context of these higher classification types.

IQ as a set of "dimensions"

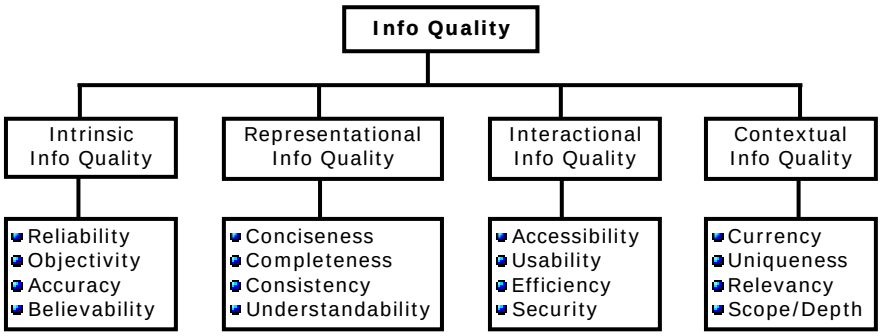
Despite the varied research contexts of the IQ frameworks examined, a close analysis of the literature reveals a remarkable commonality amongst the eventual elements identified by researchers as being important "dimensions" of IQ. These include such traditional dimensions as accuracy, consistency, timeliness, completeness, accessibility, objectiveness and relevancy. Table 1 provides a summary of the most common dimensions and the frequency with which they were included in the twenty one frameworks examined. Dimensions are named and the number of times they appear in the frameworks is recorded, followed by a short definition of each dimension.

Table 1. The Common Dimensions of IQ/DQ (1996 – 2007)

	Dimension	# of times	Definitions & Relating Dimensions
1	Reliability	17	The degree to which information is worthy of being depended on. Is built from other dimensions relating to authority, authorship and reputation.
2	Accuracy	14	The degree to which information is correct, or free from error
3	Timeliness/Currency	14	The degree to which information is up-to-date, relative to the task at hand
4	Scope/Depth	13	The degree to which the amount of information available from a source has the appropriate amount (or coverage) of information required.
5	Relevancy	12	The degree to which information is applicable and helpful for the task at hand. Includes other dimensions such as useful.
6	Accessibility & Availability	10	The degree to which information is easily retrievable by information seekers. Refers to both a physical access (i.e. through a network or internet) and cognitive access (i.e. easily read).
7	Usability	9	The degree to which information is can be easily found (i.e. navigated) and easily used.
8	Consistency	8	The degree to which information is presented in an orderly, logical format that is compatible with other information contained within the same place
9	Objectivity	8	The degree to which information is aware of (i.e. stated), or free from bias.
10	Understandability	9	the degree to which information is capable of being understood or interpreted.
11	Completeness	9	The degree to which all the necessary parts or elements of the required information are present.
12	Security	9	The degree to which information is considered safe because of appropriate restricted access.
13	Value-Added	8	The degree to which information delivers benefit by providing unique or distinct material.
14	Concise	6	The degree to which information is expressed in a compact, easy to understand manner.
15	Believability	5	The degree to which information is regarded as true or credible, and therefore capable of being believed.
16	Efficiency	3	The degree to which information is able to quickly meet the 'information needs' of a searcher.

These sixteen dimensions recorded in Table 1 are presented in figure 4 in the context of the proposed categories associated with the CC/LC model of IQ. Conceptually, the model is comparable to Wang & Strong's (see figure 1) in that it conceptualises the IQ dimensions into four IQ categories, with the only difference being the renaming of "accessibility IQ" to "interactional IQ", making all four categories adjective named. The overall conceptual landscape of the IQ dimensions associated with each category also differs slightly. Where Wang & Strong named 15 dimensions, the current framework names 16, with notably more dimensions associated with the interactional IQ (previously "accessibility IQ") category.

Figure 4. The Categories & Dimensions of the CC/LC model of IQ



In addition, the current model is driven to consider the assertion from Bovee *et al.*[37] that descriptors such as "reputation" imply information integrity, rather than provide a quantifiable construct with which to measure actual IQ. Accordingly, the previous intrinsic IQ dimension of *reputation* has been replaced with *reliability*, a measurable construct that facilitates users' value judgments in relation to intrinsic IQ. The current model also moves the *completeness* dimension out of the contextual IQ category, and into representational IQ. Unlike the original model, representational IQ is not seen as indicative of the format of information. Instead, representational IQ is the "content" of the information. It is seen as the tangible representation of interaction between information-output and information-producer, and the cognitive interaction between information-content and information-receiver. Finally, the interactional (previously *accessibility*) IQ category includes two additional constructs, usability and efficiency.

IQ Categories & Dimensions: *Discussion*

In the literature review IQ was proposed to be an evolving, moving entity, with user interaction taking place throughout the information life-cycle. Value-judgments, therefore, are made at multiple stages of interaction, by both the producers and retrievers of information. The proposed CC/LC model of IQ seeks to contextualise user/information interaction in a way that provides a better investigative framework from which to examine user perceptions of IQ. The specific IQ characteristics, or dimensions, are considered to be clusters of similar types of dimensions, which fall into four broad classifications, namely: intrinsic IQ; representational IQ; interactional IQ and contextual IQ.

Intrinsic IQ

In the context of the CC/CL model of IQ, intrinsic IQ is seen as being determined by the integral characteristics of information. That is, those essential characteristics considered to give information its degree of integrity. The dimensions associated with intrinsic IQ include; (1) reliability; (2) accuracy; (3) objectivity; and (4) believability.

As a construct, reliability is an IQ dimension built on observable characteristics such as authorship, which implies other IQ attributes such as *authority* and *reputation.*[38]. Importantly, reliability denotes the presence of dimensions such as *objectivity*, *accuracy* and *believability*, in that without these characteristics, information would be considered, by the discerning recipient, to be unreliable. All four of these dimensions then, are considered "intrinsic" characteristics of information, and must exist within (considered to be) quality information, regardless of its system context.

Importantly, like the clusters of dimensions associated with each of the four IQ categories; reliability, accuracy, objectivity and believability are seen as being co-dimensions[39], in that not only are they often judged using the same information characteristics, but they often imply each other's presence. For example, believability describes the so called credibility of information, and like reliability, is intrinsically linked with characteristics such as authorship, and co-dimensions like accuracy and objectivity.

Representational IQ

Where dimensions such as reliability, believability, accuracy and objectivity represent the intrinsic nature of information; the dimensions of (1) conciseness; (2) understandability; (3) completeness; and (4) consistency; represent what Wang & Strong classified as the "*representational*" characteristics of IQ.

Conceptually, these four dimensions characterise the representation of the actual information, constituting not so much the format (or presentation) of the data, but the actual content contained within the data. Bovee *et al.*,[40] contend that characteristics such as completeness and consistency physically represent integrity IQ, the way that previously discussed characteristics such as reliability and believability imply integrity IQ. This is summed up by what the authors' call information's *existence*, in that these types of information characteristics, unlike intrinsic characteristics, require the information to be viewed and examined in order for a value-judgment to be made.

From an information production perspective, the CC/LC contends that the dimensions of conciseness, understandability, completeness and consistency are demonstrative of the skill level of the information producer. Moreover, they also engender the information retriever to engage their own skill-set when making value-judgments related to them. Put simply, the user will make representational IQ value-judgments relative to their own cognitive ability and skill.

Interactional IQ

In the CC/LC model of IQ, interactional characteristics of information are gained at the pragmatic[41], or presentation[42] stage of the IQ life-cycle. The model contends this is where users make value judgments of information according to their technical/interactive experience and skills. Importantly, these value-judgements do not so much relate to the actual content of information, or more specifically a user's cognitive interaction with the content of information. The perceptive IQ value judgments made in regards to (1) usability; (2) accessibility; (3) efficiency; and (4) security; relate to the more motor aspects of user/information interaction, and include such characteristics as how easily information can be located or found and retrieved.

With this said, the model also recognises the inter-connectivity of IQ dimensions in general. As a characteristic of information, in the context of interactional IQ, *efficiency* would typically represent the ease with which information can meet a user's information need, and be value-

judged according to users being able to quickly find what they are looking for. That is; navigatability. It is therefore related to other interactional IQ dimensions such as usability and accessibility. Efficiency also, however, implies other information characteristics such as consistency and conciseness, which are classified as representational IQ dimensions. This brings up an important point about the development and structure of the CC/LC model of IQ. As a framework, the CC/LC has been developed to guide the conceptual classifications of the multi-dimensional phenomenon that is information quality. In conceptualising something of the interactive user/information processes involved with information creation, presentation, seeking, value-judgements, and ultimate retrieval, the model recognises that information production and information use are a continuum, and – although for the sake of clarity there is a definitive structure to the framework, where one section begins and another ends, is, and should be, relatively fluid.

Contextual IQ

Contextual IQ is made up of such quality dimensions as; (1) currency (up-to-date/recency); (2) uniqueness (innovativeness); (3) relevancy; and (4) scope/depth. Most often it relates to the actual content of information, and is directly related to the information needs of the information seeker . Where value-judgments are made of the dimensions associated with representational IQ according to the seekers own information skill, contextual IQ value-judgments are made according to what the seeker is specifically looking for. This direct relationship between contextual IQ dimensions and user information need may account for why the associated dimensions have become a central focus in systems and Web IQ research, as they are the characteristics which best represent *why* the user is engaging the system.

Recent research into systems, and particularly Web IQ[43] have positioned the contextual and interactional IQ related dimensions as central to information seekers' value-judgment processes. This view is mirrored in much of the information seeking behaviour (ISB) and information retrieval (IR) research, where the relevancy dimension is considered of particular importance[44].

Contextual IQ is problematic to information producers because currency, relevancy, uniqueness, and scope/depth are relative terms. That is; the "right", or "right amount" of information or detail depends on contextual elements such as a seeker's individual information need[45], and these are elements that the information producer may have little to no control over. For the information producer then, contextual IQ relies on them knowing their audience, and is an important element of IQ production only if the producer would have the seeker reuse their system[46].

Table 2 presents the sixteen dimensions of the CC/LC model of IQ in the context of each of their categories, along with the general impacting factor seen to govern users' IQ perceptions.

Implications and Conclusion

Wang & Strong established the now widely accepted paradigm that systems quality, as it relates to data/information quality, is information that is "fit-for-use/purpose". This recognises that IQ is determined in the context of specific user/information interactions. The CC/LC of IQ provides a conceptual framework by which the specific contexts of user/information interaction can be established, facilitating a contextual understanding of the various dimensions proposed to be central to IQ.

Table 2. Categories & Dimensions of IQ, and factors that influence user perceptions

IQ Category	IQ Dimensions	General Impacting Factors*	
		Information Producer	***Information Retriever***
Intrinsic IQ	• Reliability, • Objectivity, • Accuracy, • Believability	• Producer's knowledge of the subject	• User's knowledge
Representational IQ	• Conciseness, • Completeness, • Consistency, • Understandability	• Producer's informatic and/or language skill	• User's informatic and/or language skill
Interactional IQ	• Accessibility, • Usability, • Efficiency, • Security	• Producer's motivation to deliver information	• User's experiential skill using the system
Contextual IQ	• Currency, • Uniqueness, • Relevancy, • Scope/Depth	• Producer's knowledge of their user	• User's information need or task

*Impacting Factors: The general impact factors are a broad sweep of user characteristics in relation to whether a user is an information producer or information retriever. "Individual differences" between producers and receivers are seen as further impacting these general characteristics.

At the broadest level, the model establishes the two most divergent information contexts as being information-producer or information-retriever. Establishing this fundamental difference in context is seen as being central to any investigation of user IQ perceptions[47]. This is because, while the individual IQ categories and dimensions remain the same, how the user engages these elements can vary sharply, depending on whether they are the producer or retriever of the system's information. For example, how users engage their perceptions relating to the issue of copyright, seen as being part of the *security* IQ dimension, could be quite different depending on whether they were producing or trying to retrieve material. Pay-for-view, another element of security IQ, would also find producers and retrievers on opposite ends of the security spectrum.

The CC/LC model of IQ provides for researchers, a framework by which to engage users and information system in a contextual, and therefore meaningful way. It does this by:

1.) Separating information production and information retrieval into separate information contexts, thereby allowing the researcher to develop an understanding of how these two distinct groups of users might engage individual dimensions of IQ;

2.) Placing the IQ categories and dimensions into a user/information interaction life-cycle, thereby allowing the researcher to conceptualise and empirically test the types of value-judgements users might actually make at specific points of user/information interaction.

Author's Note:

The CC/LC model of IQ has been empirically tested in the PhD research "*User perceptions of information quality in World Wide Web information retrieval behaviour*". The dissertation used the framework to investigate the IQ perceptions of 80 "high end" academic users who frequently engage the Web for the retrieval of high quality information.

About the Author:

Dr Shirlee-ann Knight works as a senior business analyst for the Department of Agriculture and Food, W.A. (DAFWA) and is an adjunct researcher with Edith Cowan University.

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Prior to devoting her time to research and systems analysis, Shirlee-ann worked as an instructional designer, and was involved in interface design and content management components of MIS's (at ECU) school-wide implementation of WebCT. She was also awarded the "Coursework Supervisor of the Year – 2004" (an award nominated and voted for by students at ECU) for her supervision of the online Information Retrieval & Document Management unit, and lectured in Web Usability and Web Applications.

EndNotes

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