Preface

Abstract

This preface addresses the book Information Quality Management: Theory and Applications*. It discusses the importance of information quality (IQ) and presents examples of IQ documented problems. The preface discusses the importance of information quality (IQ) and IQ dimensions. It presents examples of documented IQ problems and relates these problems to IQ dimensions. It itemises with brief descriptions the structure of this book. This book comprises 12 chapters organised into five sections covering various theoretical and practical issues. It provides insights and support for academic professionals as well as for practitioners concerned with the management of information.*

Overview

The current era is associated with widespread and successive waves of technology-driven innovations in information technology (IT). Technologies, such as the Internet, electronic commerce, World Wide Web (WWW), and mobile commerce, bring with them ubiquitous connectivity, real-time access, and overwhelming volumes of data and information. More and more electronically captured information needs to be processed, stored, and distributed through IT-based business systems. Information is shared amongst various decision makers within organisations and between supply chain partners not only to benchmark, amend, or formulate competitive strategies but also to control day-to-day operations and to solve problems on a real-time basis (Al-Hakim, 2003). The world has experienced a transition from an industrial economy to an information economy. Data and information have become as much a strategic necessity for an organisation's well being and future success as oxygen is to human life (Eckerson, 2002). IT allows organisations to collect great volumes of data. Vast databases holding terabytes of data and information are becoming commonplace (Abbott, 2001).

The literature emphasises that enterprises have far more data than they can possibly use. Yet, at the same time, they do not have the data they actually need (Abbott, 2001; Eckerson, 2002). Furthermore, the stored data and information may be obsolete, ambiguous, inaccurate, or incomplete. In other words, enterprises have achieved "quantity" of data and information but not necessarily the "quality" of either (Pierce, 2005). In 1999, Bill Gates, the founder of Microsoft, stated:

The most meaningful way to differentiate your company from your competitors, the best way to put distance between you and the crowd, is to do an outstanding job with information. How you can gather, manage and use information will determine whether you win or lose.

Gates' statement implies there are some issues that traditional information management systems have not addressed. One critical issue in particular is the quality of information an organisation should gather, manage, and use. The literature suggests that information quality (IQ) problems are becoming increasingly prevalent. The growth of data warehouses and communication and information technologies has increased the need for, and awareness of, high IQ management in organisations. IQ has been rated a top concern to data and information consumers and has been reported as a major factor affecting the success of information systems. There is strong evidence to suggest that IQ has become a critical concern of organisations (Al-Hakim & Xu, 2004; Lee, Strong, Kahn, & Wang, 2002; Redman, 2001; Wand & Wang, 1996). Firms become so critically dependent on information that IQ problems must be identified and treated as urgently as possible. Poor quality of data and information can have a deleterious impact on decision making and therefore on the overall effectiveness of an enterprise. Incorrect and misleading information associated with an enterprise's production and service provision jeopardise both customer relationships and customer satisfaction and ultimately have a negative effect on revenue. Poor information quality is not only prevalent in manufacturing and service organisations; it can also be at the root of many issues of national and international importance which dominate the news (Redman, 2004). Table 1 illustrates some well documented problems associated with poor information quality.

Information and Data

Turban, Aronson, and Liang (2005) provide the following commonly accepted view of the terms information and data:

- **Data:** Items about things, events, activities, and transactions are recorded, classified, and stored but are not organised to convey any specific meaning. Data items can be numeric, alphanumeric, figures, sounds, or images.
- **Information:** Data that has been organised in a manner that gives meaning for the recipient. They confirm something the recipient knows, or may have "surprise" value by revealing something not known.

These definitions clarify the relationship between data and information. They are consistent with the concept of information product (Ballou et al., 1998; Huang et al., 1999) in which information is a product of an information manufacturing system. The input for this information manufacturing system is data. Similar to a product manufacturing system, an information manufacturing system is hierarchical in that information output from a certain stage can be considered data for the next stage of the information manufacturing system.

From this perspective, the term information can be used to refer to both data and information (Strong, Lee, & Wang, 1997). However, the reverse is not always applicable; that is, data collected and stored in a data warehouse cannot be considered information as these data are not yet organised and processed to give meaning for a recipient. Wang urges organisations to manage information as they manage products if they want to increase productivity. Wang finds an analogy between quality issues in product manufacturing and those in information manufacturing and asserts that information manufacturing can be viewed as processing system acting on raw data to produce information products. There are differences between product manufacturing and information manufacturing that can be classified under five main headings: intangibility, input, users, consumption, and handling (Table 2). However, the differences listed in Table 2 will not affect the main idea behind the analogy proposed by Wang between product and information (Al-Hakim, 2004).

Earlier literature dealing with information quality as well as some recent publications use information quality (IQ) and data quality (DQ) interchangeably. While information quality as the quality of the information product implies data quality or the quality of its

Table 1. Examples of some documented problems associated with IQ

Field	Problem	Reason	IQ Dimension
Space Industry	The spacecraft launched by NASA on December 11, 1998, to observe the seasonal climate changes on Mars was lost upon arrival at the planet on September 23, 1999.	It is found that the "root cause" of the loss of the spacecraft was the "the failed translation of English units into metric units in a segment of ground-based, navigation-related mission software" (Isbell & Savage, 1999). The IQ problem here is the use of two different types of information obtained from two measurement systems.	Consistency of representation, compatibility, coherency.
Mine Safety and Health	On July 24, 2002, miners working underground in the Quecreek coal mine in Western Pennsylvania (USA) accidentally broke into an adjacent abandoned mine, which unleashed millions of gallons of water and trapped nine men for three days.	The report of the Mine Safety and Health Administration (MSHA) found that the primary cause of the water inundation was use of undated information obtained from old mine map (MSHA, 2003).	Timeliness, free-of-error.
Bosnian War	On May 8, 1999, NATO forces accidentally bombed the Chinese Embassy in Belgrade.	The bombing instruction was based on outdated data. The data regarding the movement of the location of the Chinese Embassy in 1996 was undated in the NATA database and on their maps (Lehrer, 1999).	Timeliness.

Table 1. continued

Legal System - Death Penalty	In March 2000, a judge acquitted Mr. Green from the 1992 murder of a Starke woman. Mr. Green became one of 21 inmates released from death row in Florida (Kestin, 2000).	A study conducted by Columbia Law School found that during a period of 23 years, the overall rate of prejudicial errors in the American capital punishment system was 68% (Columbia News, 2000). The three most common errors are: (1) incompetent lawyers (37%); (2) suppression of evidence of innocence (19%); and (3) faulty instruction to jurors (20%).	Accuracy, believability, coherency, completeness, ease of understanding, relevancy, reputation.
Terrorism	On September 11, 2001, a series of terrorist attacks destroyed the twin towers of the World Trade Center and severely damaged the Pentagon.	The 9/11 Commission Report depicted a failure to effectively share terrorism warning information and to link the collective knowledge of the agents in the field of national priority (The 9/11 Commission Report, 2004).	Coherency, objectivity, value-added.
Weapons of Mass Destruction	The United States government asserted that [the former Iraqi dictator] Saddam Hussein had reconstituted his nuclear weapons program, had biological weapons and mobile biological weapon production facilities, and had stockpiled and was producing chemical weapons.	The final report of a special commission confirms that "not one bit of it could be confirmed when the war was over." The Commission concludes that "our study of Iraq found several situations where key information failed to reach those who needed it" (Commission WMD, 2005).	Timeliness, free-of-error, completeness, coherency.
Health - Surgery	Two women with the same first name attended a hospital in the same day to have a breast biopsy. One had breast cancer. One did not. The woman with the breast cancer died after nine months.	It was discovered that the biopsy information results had been mixed up. The woman with the breast cancer died after nine months and the patient without breast cancer had endured months of chemotherapy and was minus a breast (Pirani, 2004).	Accuracy, interpretability, free-of-error, conciseness of representation.
Industry - Refinery	On March 23, 2005, the BP Texas City refinery in the U.S. suffered a huge blast. The blast claimed 15 lives and injured 170 (BBC, 2005a).	The interim report into the tragedy has found that failure to follow the proper procedure (which is one type of information) contributed to the explosion, that is, IQ problem.	Accessibility, ease of understanding, interpretability.

Table 1. continued

Finance - Share Market	On December 9, 2005, brokers at Mizuho Securities tried to sell 610,000 shares at 1 yen (0.8 US cents) each. The company had meant to sell one share for 610,000 yen – US$5,065 (BBC, 2005b).	Mizuho said the brokerage had purchased the majority of the phantom shares it sold, but the error has so far caused the company a loss of 27 billion yen or US$21.6 billion. It is announced that this chaos into Japan market trading was a result of a "typing error" (BBC, 2005b), that is, problem in information quality.	Free-of-error, interpretability, objectivity.
Media & Mine Safety	On January 2, 2006, an explosion at the Sago mine (West Virginia, USA) trapped 13 workers. Shortly before midnight on Tuesday, a statement that 12 miners had been found alive was made on several national TV stations and the broadcast prompted jubilant scenes as friends and relatives celebrated. But the euphoria was short lived. Just hours after the banner headlines announced that the 12 miners were safe, rescue workers found their bodies (Associated Press, 2006).	Only one miner out of the 13 miners survived. The sole survivor was taken to the hospital where doctors said his condition was critical. Ben Hatfield, president of mine owner, International Coal Group, blamed the earlier report on "miscommunication."	Accuracy, accessibility, believability, reputation.

raw material "data," the reverse is not always true. Good IQ implies good DQ and poor DQ causes poor IQ. However, good DQ may not necessarily lead to good IQ. Poor IQ may be caused by errors within the process of transforming data into information. A researcher or analyst may collect accurate, complete, and timely data but may conclude from them poor quality information. IQ implies DQ and the term information quality reflects both "information quality" and "data quality." The focus of authors speaking only about DQ is primarily on the issue of data as raw material for example issues related to quality of data for data warehousing. The editor of this book has successfully oriented the authors of this book to use DQ when their research is oriented to data only and to use IQ when they deal with IQ.

Table 2. Main differences between product manufacturing and information manufacturing

Item	Difference
Intangibility	Product manufacturing system produces tangible, visible, or physical products whereas information is intangible. The quality of product can be measured with physical measures such as design specifications. The measures for quality of information are subjective and mainly based on the user's opinion and expectation.
Inputs	Product process requires raw material, experience/knowledge, and technology; while information process requires four inputs: data, experience, technology, and time.
End user	The users of the end product are undefined in the former, whereas they are clearly defined in the latter (Sen, 2001). The user of an information system is part of the system, whereas products are produced away from the users.
Consumption	The raw materials used in information manufacturing are data which can be consumed by more than one consumer without depletion, not like raw materials in product manufacturing that can only be used for single physical products. Further, information can be produced and consumed simultaneously, while products need to be produced before consumption.
Handling	Unlike products, same data and information can be transported to an undefined number of consumers simultaneously via physical carrier, for example, disk, or through an intangible way, for example, e-mail. However, both information and products can be stored and inspected before delivery to the customers. This makes information quality similar to product quality but different from service quality as the service quality cannot be stored and inspected before the delivery (Evans & Lindsay, 2005).

IQ Dimensions

Evans and Lindsay (2005) stress that quality can be a confusing concept. They provide two main reasons for this assertion: (1) people view quality using different perspectives and dimensions based on their individual roles, and (2) the meaning of quality continues to evolve as the quality profession grows and matures. Similar to product quality, IQ has no universal definition. To define IQ, it is important to comprehend both the perspective from which IQ is viewed and its dimensions. The Cambridge Dictionaries Online (2005) define perspective as "a particular way of considering something" and dimension as "a measurement of something."

Individuals have different ways of considering the quality of information as they have different wants and needs, hence, different quality standards which lead to a user-based quality perspective (Evans & Lindsey, 2005). Information users can view IQ from various

Table 3. Definitions of the common IQ dimensions used in literature and their categories (adapted from several research works)

Dimension	**Definition**	**Category**		
		Wang and Strong (1996)	Wang et al. (1995)	Lee et al. (2002)
Accessibility	The degree to which information is available, easily obtainable, or quickly retrievable when needed. Accessibility depends on the customer's circumstances.	Accessibility	Internal + External -Data / system related	Usable
Accuracy	The degree to which information represents a real-world state.	Intrinsic	Internal -Data related	Sound
Amount of Information	This dimension measures the appropriateness of volume of information to the user or task at hand.	Contextual	Internal/ External -Data related	Useful
Believability	This dimension measures the user assessment of trueness and credibility of information.	Intrinsic	Internal/ External - Data/system related	Usable
Coherency	This measures how information "hangs together" and provides one meaning to different users.	Intrinsic + contextual	Internal - Data related	Sound
Compatibility	The level to which information can be combined with other information to form certain knowledge.	Intrinsic + Contextual	Internal - Data related	Useful
Completeness	The degree to which information is sufficient enough to depict every state of the task at hand or the represented system, that is, assesses the degree of missing information.	Contextual	Internal - Data related	Sound
Conciseness of Representation	The compactness of information representation.	Represent'nal	External - Data related	Sound

Table 3. continued

Consistency of Representation	The degree of similarity and compatibility of information representation format.	Represent'nal	Internal - Data related	Sound
Ease of Manipulation	The applicability of information to different tasks.	Intrinsic	Internal - Data related	Useful
Ease of Understanding	The degree of comprehension of information.	Represent'nal	Internal - Data/system related	Useful
Free-of-error	The degree to which information is correct. This dimension measures the number, percent, or ratio of incorrect or unreliable information.	Intrinsic	Internal - Data/system related	Sound
Interpretability	The appropriateness and clarity of information language and symbols to the user.	Represent'nal	Internal - Data related	Useful
Objectivity	This dimension measures the information impartiality including information is unbiased and unprejudiced.	Intrinsic	External - Data related	Useful
Relevancy	Relevancy indicates weather information addresses the customer's needs. It reflects the level of appropriateness of information to the task under consideration.	Contextual	External - Data related	Useful
Reputation	The degree of respect and admiration of both information source and information content.	Intrinsic	External - Data related	Usable
Security	It indicates the level of either restriction on access of information or appropriateness of information back-up — protecting information from disasters.	Accessibility	Internal/ External - System related	Dependable

Table 3. continued

Timeliness	This dimension measures how up-to-date information is with respect to customer's needs or the task at hand. It reflects also how fast the information system is updated after the state of the represented real-world system changes.	Contextual	Internal/ External - Data/system related	Dependable

perspectives; as "fitness for intended use," "conformance to specifications," or "meeting or exceeding customer expectations." While these perspectives capture the essence of IQ, they are very broad definitions and are difficult to use in the measurement of quality. There is a need to identify the dimensions that can be used to measure IQ.

IQ is multidimensional. This means that organisations must use multiple measures to evaluate the quality of their information or data. Several researchers have attempted to identify the IQ dimensions. Wang, Storey, and Firth (1995) list 26 IQ dimensions, which in turn are classified into either internal view (design operation) or external view (use and value). Each of these classifications is divided into two subcategories: data-related and system-related (Wand & Wang, 1996). Wang and Strong (1996) conducted an empirical two-phase sorting study and provide the most comprehensive list of IQ attributes. Their list comprises 118 attributes. The 118 attributes are reduced to 20 dimensions, which in turn are grouped into four categories: accuracy, relevancy, representation, and accessibility. Wang and Strong (1996) reexamine their four initial categories and relabeled the first two categories and the four categories became: intrinsic, contextual, representation, and accessibility. It should be noted here that Wang and Strong use the term DQ (rather than IQ) to represent both DQ and IQ. Recently, Lee et al. (2002) developed a two-by-two conceptual model for describing IQ. The model comprises 16 dimensions, which are classified into four categories: sound information, dependable information, useful information, and usable information. Table 3 provides definitions of the most common IQ dimensions used in the literature and illustrates their categories. The last column of Table 1 links the IQ problems with IQ dimensions.

Structure of the Book

This book deals with the theoretical aspects of IQ as well as the IQ applications. It provides insights and support for:

- Professionals and researchers working in the field of information and knowledge management in general and in the field of IQ in particular
- Practitioners and managers of manufacturing and service industries concerned with the management of information

This book comprises 12 chapters organised into five sections covering various theoretical and practical issues. The following is a brief description of each section and the chapters included in them.

Section I: Processing Issues in IQ. The first section of the book comprises three chapters that cover issues associated with IQ processing including IQ metrics for entity resolution, query processing, and attributes of symbolic representation. **Chapter I**, "An Algebraic Approach to Data Quality Metrics for Entity Resolution Over Large Datasets" by John Talburt, Richard Wang, Kimberly Hess, and Emily Kuo, introduces abstract algebra as a means of understanding and creating data quality metrics for entity resolution. Entity resolution is a particular form of data mining that is basic to a number of applications in both industry and government. The chapter describes current research into the creation and validation of quality metrics for entity resolution, primarily in the context of customer recognition systems. It discusses the difficulty of applying statistical cluster analysis to this problem when the datasets are large and propose an alternative index suitable for these situations. The chapter reports preliminary experimental results and outlines areas and approaches to further research in this area.

The second chapter of this section, **Chapter II**, is "Quality-Extended Query Processing for Mediation Systems" by Laure Berti-Équille. It deals with the extension and adaptation of query processing for taking into account constraints on quality of distributed data and presents a novel framework for adaptive query processing on quality-extended query declarations. This chapter attempts to find the best trade-off between the local query cost and the result quality. It discusses that quality of data and quality of service can be advantageously conciliated for tackling the problems of quality-aware query processing in distributed environments and, more generally, that opens innovative research perspectives for quality-aware adaptive query processing.

Current database technology involves processing a large volume of data in order to discover new knowledge. **Chapter III**, titled "Discovering Quality Knowledge from Relational Databases" by M. Mehdi Owrang O., deals with the quality of knowledge discovery and stresses that relational databases create new types of problems for knowledge discovery since they are normalized to avoid redundancies and update anomalies, which make them unsuitable for knowledge discovery. The chapter emphasises that a key issue in any discovery system is to ensure the consistency, accuracy, and completeness of the discovered knowledge. The chapter describes the aforementioned problems associated with the quality of the discovered knowledge and provides some solutions to avoid them.

Chapter IV, titled "Relativity of Information Quality: Ontological vs. Teleological, Internal vs. External View" by Zbigniew Gackowski, presents a qualitative inquiry into the universe of quality attributes of symbolic representation such as data and information values. It offers a rationale for a move from the internal toward the external, from the ontological to the teleological perspective. The focus is on approaches that derive attributes from established theories. The chapter illustrates four cases to offer examples of top-down, dataflow-up examination of quality attributes to demonstrate the potential of the teleological perspective.

Section II: IQ Assessment and Improvement. This section includes two chapters that deal with the challenge of assessment and improvement of information quality. **Chapter V**, titled "The Development of a Health Data Quality Programme" by Karolyn Kerr and Tony Norris, stresses that successful DQ improvement programs require viewing data quality from a holistic perspective — going beyond only the assessment of quality dimensions such as accuracy, relevance, timeliness, comparability, usability, security, and privacy of data.

The chapter emphasises that the core components of a data quality program are quality determinants, assessment framework, and implementation strategy. The chapter discusses the theoretical background of each component in order to formulate a framework for the health care sector. The chapter describes the development of a data quality evaluation framework (DQEF) and an underpinning strategy for the Ministry of Health in New Zealand and outlines the process to "institutionalise" Total Data Quality Management throughout the whole of the health sector.

Chapter VI is "Assessment and Improvement of Data and Information Quality" by Ismael Caballero and Mario Piattini. This chapter provides the theoretical background for assessing and improving information quality at organisations. It introduces IQ assessment and improvement framework through the concept of information management process (IMP). An IMP is assessed according to an information quality maturity model by using an assessment and improvement methodology. The chapter claims that the framework provides a consistent roadway for coordinating efforts and resources to manage information quality with a strategic perspective. The chapter presents a case study to illustrate the applicability of the approach.

Section III: IQ Process Mapping. To be able to effectively manage the quality of information products, professionals can employ several information management tools. However, there does not seem to be sufficient tools in place to assist the information system professionals in understanding the production process that transforms data collected by the organization into the intermediate component data and information that are then formed into the final information products that are distributed to the consumers in the organization. The third section of the book deals with data and information mapping and features two chapters. The first chapter of this section, **Chapter VII**, titled "Integrating IP-Maps with Business Process Modeling" by Elizabeth Pierce, introduces the concept of information production map (IP-Map). The chapter takes the basic constructs of the IP-Map diagram and demonstrates how they can be combined with the event-driven process chain methodology's family of diagrams. This extended family of diagrams can be used to more fully describe the organizational, procedural, informational, and communication structure of a business process while at the same time highlighting the manufacture of the information products used by that business process. The chapter concludes with a review of requirements for a software package that will allow analysts to model and explore their business processes with an emphasis on improving the quality of the organisation's information products.

This second chapter of this part, **Chapter VIII**, "Procedure for Mapping Information Flow: A Case of Surgery Management Process" by Latif Al-Hakim, proposes a procedure to map information and uses the surgery management process (SMP) as a case to illustrate the steps of the procedure. The chapter discusses the issues that make information mapping of SMP a challenging task and explains the difficulties associated with traditional process mapping techniques in mapping information and determining the interdependencies of various elements of SMP activities. The proposed procedure integrates a structured process mapping technique known as IDEF0 with another structured technique referred to as dependency structured matrix (DSM) to map the information of the process. The chapter indicates that it is possible to reduce feedback from other activities that affect the performance of SMP by administratively controlling the information flow through certain activities of SMP.

Section IV. IQ Applications in Manufacturing and Management. The fourth section of the book presents two chapters that deal with issues related to engineering management, product information quality (PIQ), and engineering asset management.

Chapter IX, "A Methodology for Information Quality Assessment in the Designing and Manufacturing Processes of Mechanical Products" by Ying Su and Zhanming Jin, concentrates on IQ related to designing and manufacturing a product, that is, product information quality (PIQ). It emphasises that PIQ is critical in manufacturing enterprises. Yet, the IQ field lacks comprehensive methodologies for PIQ evaluation. The chapter develops such a methodology, which is called activity-based measuring and evaluating of PIQ (AMEQ) to form a basis for PIQ measurement and evaluation. The methodology is illustrated through a business case.

Chapter X, titled "Information Quality in Engineering Asset Management" by Andy Koronios and Shien Lin, discusses the criticality and important issues of information quality associated with the management of engineering assets. They argue that it is essential to ensure the quality of data in monitoring systems, control systems, maintenance systems, procurement systems, logistics systems, and range of mission support applications in order to facilitate effective asset management. The chapter's authors hope that a better understanding of the current issues and emerging key factors for ensuring high quality asset management data will not only raise the general information quality awareness in engineering asset management organisations, but also assist managers and IT professionals in obtaining an insightful and overall appreciation about what information quality problems are in engineering asset management and why they have emerged.

Section V. IQ Applications in Developing Countries. This section comprises two chapters that provide insight information about IQ application in China and Malaysia.

China is experiencing a significant reform in its decision mechanisms, and this is causing a change in the quality requirement for information and the necessity of total quality management for information. **Chapter XI**, "Quality Management Practices Regarding Statistical and Financial Data in China" by Zhenguo Yu and Ying Wang, presents a survey into quality management practices regarding statistics and financial data in China. The chapter stresses the needs for total information quality management in China and stresses that Chinese people understand the quality of the information based on multidimensional metrics. It explores IQ management organizations in China and the legislations against information fraud and information disclosures.

The last chapter in this book, **Chapter XII**, titled "The Effects of Information Quality on Supply Chain Performance: New Evidence from Malaysia" by Suhaiza Zailani and R. Premkumar, presents a study conducted in Malaysia. It introduces how information quality plays an important role in a supply chain performance. This chapter examines the factors influencing information quality and investigates the influences of information quality on supply chain performance in Malaysia. The chapter finds that the extent of information quality will increase supply chain performance and the extent of information quality is influenced by technological, organizational, and environmental characteristics.

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