Information Quality Benchmarks: Product and Service Performance

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Information quality (IQ) is an inexact science in terms of assessment and benchmarks. Although various aspects of quality and information have been investigated [1, 4, 6, 7, 9, 12], there is still a critical need for a methodology that assesses how well organizations develop information products and deliver information services to consumers. Benchmarks developed from such a methodology can help compare information quality across organizations, and provide a baseline for assessing IQ improvements.

This article presents a methodology and tests its efficacy through a rigorous case study. The players in our study include information producers, who generate and provide information; information custodians, who provide and manage computing resources for storing, maintaining, and securing information; and information consumers, who access and use information [9]. We extend previous research on managing information as product to incorporate the service characteristics of information delivery. We draw upon the general quality literature, which discusses quality as conformance to specification and as exceeding consumer expectations. Our key contributions are:

- Developing a two-by-two conceptual model for describing IQ. The columns capture quality as conformance to specifications and as exceeding consumer expectations, and the rows capture quality from its product and service aspects. We refer to this model as the product and service performance model for information quality (PSP/IQ).
- Integrating the IQ dimensions identified in our previous research into the PSP/IQ model. Since a measurement instrument for the IQ dimensions has

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already been developed, this integration provides the basis for IQ assessment and benchmarks within the context of the PSP/IQ model.
- Demonstrating the efficacy of the PSP/IQ model in three large healthcare organizations.

The PSP/IQ Model

Quality has been defined as fitness for use, or the extent to which a product successfully serves the purposes of consumers [3]. While fitness for use captures the essence of quality, it is difficult to measure quality using this broad definition. The quality literature provides more specific views, describing quality in one of four general ways: as excellence, value, conformance to specifications, or meeting or exceeding consumer expectations [7]. The first two views of quality are problematic. Defining quality as excellence is subjective and provides no practical guidance for improving quality. It also ignores the potentially high costs of achieving excellence. Defining quality as value captures tradeoffs between excellence and costs, but other attributes of importance to consumers may be ignored. Furthermore, quality as value blends excellence and worth, resulting in a hybrid concept of affordable excellence.

We assigned the latter two views of quality, *conforming to specifications*, and *meeting or exceeding consumer expectations*, as the columns of the PSP/IQ model (see Table 1). Producers and custodians favor the conformance to specifications definition of quality since it usually can be defined and measured. Specifications are established to ensure products and services are free of deficiencies that may interfere with their use. Thus, fitness for use can be operationalized as meeting a specification, if the specification is adequately developed.

The meeting or exceeding consumer expectations definition of quality assumes that simply conforming to specifications is not adequate, and the product or service must meet or exceed consumer expectations. Information must be useful and add value to the tasks of information consumers. Product and service designers and marketing professionals tend to take this view of quality. While this definition may capture the essence of fitness for use, it can be difficult to measure since consumer expectations may change over time.

For the two rows of the PSP/IQ model, we chose *product quality* and *service quality*. Recent literature has drawn distinctions between these two important aspects of IQ [12]. Product quality includes dimensions related to product features, and

Table 1. Aspects of the PSP/IQ model.

	Conforms to Specifications	Meets or Exceeds Consumer Expectations
Product Quality	Sound Information The characteristics of the information supplied meet IQ standards.	Useful Information The information supplied meets information consumer task needs.
Service Quality	Dependable Information The process of converting data into information meets standards.	Usable Information The process of converting data into information exceeds information consumer needs.

involves the tangible measures of accuracy, completeness, and freedom from errors. Service quality includes dimensions related to the service delivery process as well as addressing the intangible measures of ease of manipulation, security, and added value of the information to consumers.

Both product and service quality are important aspects of IQ, although the conventional view of IQ is product-oriented [6, 11]. A product is a tangible item; when you buy a product, you own it; products can be produced and stored, then sold later; products can be used and often re-used later [5]. Information as a product takes an engineering view. It focuses on the activities needed to put and maintain data in databases. For example, the information production process can be thought of as a manufacturing process with an end-product of information stored in a database [1]. The process of changing information values resembles product enhancement.

Information also can be conceptualized as a service. A service is a deed performed by one party/machine for another; it is experienced, used, or consumed; it is perishable, for you cannot keep it; it is produced and consumed simultaneously [5]. The process of converting data to information has the typical characteristics of a service, for it often involves customized, personal interaction between information technology (IT) staff and users [6]. Providing the support, tools, and assistance in this conversion is a traditional role of IT departments. Failing to consider information as a service misses some aspects important to information consumers [6]. Furthermore, information consumers do not clearly distinguish between the quality characteristics of information and the quality characteristics of the hardware and software systems that deliver that information. Information as a service focuses on the activities occurring after information is stored as an end-product in a database: obtaining and using information. Information service quality addresses those latent product attributes that become apparent during use, such as whether information is easily accessible and can easily be aggregated and manipulated.

While products and services have distinct characteristics, they are not as dichotomized as this discussion suggests [8]. Products are typically assumed to be tangibles, while services are intangibles. Products, however, often have intangible aspects, and many services have tangible components [12]. Following are descriptions of the four quadrants in the PSP/IQ model:

- The Product Quality/Conforms to Specifications quadrant indicates database information meets standards of accuracy, completeness, and freedom-from-error. A database with 99% accuracy and completeness of inventory information, for example, would have high quality for this quadrant. We label this quadrant sound information or soundness.
- The Service Quality/Conforms to Specifications quadrant indicates a process by which information consumers acquire the product for their use. For example, if consumers regularly receive inventory information in a timely manner, then the basic service specifications for the information product are met. We label this quadrant dependable information or dependability.
- The Product Quality/Meets Consumer Expectations quadrant adds the requirement that the information product be useful and relevant to the needs of information consumers. If consumers need inventory information broken down by warehouse location, for example, then the inventory information product is of high quality only if this breakdown exists. We label this quadrant useful information or usefulness.

- The Service Quality/Meets Consumer Expectations quadrant adds the requirement that information consumers can easily obtain and manipulate information that adds value to their tasks. Consumers must be able to use the query language provided to retrieve the inventory information needed to make effective decisions, for example. We label this quadrant usable information or usability.

Operationalizing the PSP/IQ Model

In our previous research [11], we determined the essential dimensions of IQ for delivering high quality information (see Table 2). We mapped these dimensions into the PSP/IQ quadrants according to whether they can be achieved by conformance to specifications or by considering the changing expectations of consumers performing organizational tasks. Information producers and information custodians, especially those working in a Total Quality Management (TQM) environment, understand producing to specifications and the broader needs of the market beyond specifications. We also considered whether each IQ dimension is primarily an aspect of product quality or service quality. Distinguishing IQ dimensions in this way should help information producers and custodians understand the requirements for delivering high-quality information.

Table 2. Dimensions of information quality.

Dimensions	Definitions
Accessibility	the extent to which information is available, or easily and quickly retrievable
Appropriate Amount of Information	the extent to which the volume of information is appropriate for the task at hand
Believability	the extent to which information is regarded as true and credible
Completeness	the extent to which information is not missing and is of sufficient breadth and depth for the task at hand
Concise Representation	the extent to which information is compactly represented
Consistent Representation	the extent to which information is presented in the same format
Ease of Manipulation	the extent to which information is easy to manipulate and apply to different tasks
Free-of-Error	the extent to which information is correct and reliable
Interpretability	the extent to which information is in appropriate languages, symbols, and units, and the definitions are clear
Objectivity	the extent to which information is unbiased, unprejudiced, and impartial
Relevancy	the extent to which information is applicable and helpful for the task at hand
Reputation	the extent to which information is highly regarded in terms of its source or content
Security	the extent to which access to information is restricted appropriately to maintain its security
Timeliness	the extent to which the information is sufficiently up-to-date for the task at hand
Understandability	the extent to which information is easily comprehended
Value-Added	the extent to which information is beneficial and provides advantages from its use

Mapping the IQ dimensions into the model also tailors it to IQ. The IQ dimensions have demonstrated validity, and achieving high quality along these dimensions is necessary for consumers to consider information to be of high quality. A measurement instrument has been developed to assess information quality for each dimension, providing a benchmark of the current IQ status of an organization.

We surveyed 45 professionals to determine which IQ dimensions belong in each quadrant of the PSP/IQ Model. The first page of our questionnaire listed the characteristics of products and services, and the definitions of conforming to specifications and of meeting/exceeding consumer expectations. The second page listed the IQ dimensions in alphabetical order with the definition of each dimension, as shown in Table 2. For each IQ dimension, the respondent checked one of two boxes, labeled product and service. The third page was similar, but the boxes were labeled conforms to specifications and meets/exceeds consumer expectations.

For most dimensions the classification was clear, with over 70% of the respondents agreeing on a specific row and column assignment. The product/service assignment of each dimension had a lower threshold value of 60% agreement, which is consistent with the marketing literature viewing the product/service distinction as a continuum.

The second phase of our analysis involved creating a composite variable representing respondents' quadrant assignments. A dimension was assigned to a quadrant when a majority (over 50%) of the respondents selected this assignment. In all cases, this quadrant assignment agreed with the separate row/column assignments. This two-phased analysis provided a means of obtaining consensus in the assignment of dimensions to quadrants.

When we mapped the IQ dimensions into the PSP/IQ model, we found all dimensions but two fell solidly into one of the four quadrants. As illustrated in Table 3, the two dimensions in italics in the useful information quadrant are borderline assignments. Objectivity falls in the product row, but it falls close to the middle of

Table 3. Mapping the IQ dimensions into the PSP/IQ model.

	Conforms to Specifications	**Meets or Exceeds Consumer Expectations**
Product Quality	Sound Information • Free-of-Error • Concise Representation • Completeness • Consistent Representation	Useful Information • Appropriate Amount • Relevancy • Understandability • *Interpretability* • *Objectivity*
Service Quality	Dependable Information • Timeliness • Security	Usable Information • Believability • Accessibility • Ease of Manipulation • Reputation • Value-Added

the two columns, whereas interpretability falls close to the middle of the two columns and the two rows. Further details of the quadrant assignments are as follows:

- Sound Information. The IQ dimensions in this quadrant are tangible and measurable against a specification. The soundness of information is usually independent of task and decision. An information consumer requires information to be error free and well represented. Missing information can lead to incorrect inferences and poor decisions. Consumers must know the conventions used to represent data, whether a date field of 05/03/98 represents May 3, 1998 using American date conventions, or March 5, 1998 using European conventions, for example. Consistent representation ensures a minimum level of interpretability and understandability is achieved.
- Dependable Information. The IQ dimensions in this quadrant generally cannot be evaluated a priori from characteristics of data in a database. Like any service, information delivery can only be evaluated after it occurs. Dependable information is current, secure, and provided in a timely manner to support the task at hand.
- Useful Information. The IQ dimensions in this quadrant are task dependent characteristics. The information is relevant to the consumer's task and sufficient to support decision making. Information consumers gain greater confidence using objective information.
- Usable Information. The IQ dimensions in this quadrant distinguish one service from another. This can only be evaluated from a consumer's point of view and is based on the task or decision at hand. To use information, consumers must be able to access it and tailor it to their needs. These dimensions depend on the computer systems in place between the consumer and the stored data. Consumers can use the information when it is believable and reputable, as well as beneficial. Benefits are often intangible and difficult to measure, but are key to delivering high quality information. For example, an online broker service provides usable and valuable information if investors, in net, make more money using less time than with traditional services. Investment information can be sound, dependable, and relevant to investors without necessarily being usable.

Case Study of Healthcare Organizations

We demonstrated the efficacy of the PSP/IQ model using data collected from three large healthcare organizations. Approximately 75 people in each organization completed a 70-item questionnaire assessing the quality of their patient information on the IQ dimensions. The items were measured on a 10-point Likert scale, with 1 the lowest, 5 average, and 10 the highest quality. We computed the mean value for each quadrant from the values for the IQ dimensions in that quadrant. Table 4 shows these values for the three organizations, as well as the overall mean for the quadrant across all three organizations. Our survey instrument was developed, tested, and used for another research study, and has established validity and reliability [2].

A chi-square test showed no significant differences between the organizations. Thus, the overall mean was used to represent the organizations. We also checked for consistency within the dimensions representing each quadrant. The only outlier was the value-added dimension, which had a high value relative to the other dimensions in the usable information quadrant. To avoid distorting the value for the usable information quadrant, the means reported in Table 4 were computed without the value-added dimension. The overall mean for the usable quadrant without value-added was

Table 4. Average values for IQ in the four quadrants of the PSP/IQ model.

	Usable (Service Quality Meets/Exceeds Consumer Expectations)	Sound (Product Quality Conforms to Specifications)	Dependable (Service Quality Conforms to Specifications)	Useful (Product Quality Meets/Exceeds Consumer Expectations)
Firm 1	4.57	4.73	5.23	5.43
Firm 2	4.46	4.71	5.28	5.26
Firm 3	4.68	4.95	5.38	5.67
Overall	***4.57***	***4.80***	***5.30***	***5.45***

4.57; with the value-added dimension it was 4.88. In either case, the usable information quadrant was below average.

The results indicated a clear pattern for all three companies across the four quadrants. All three organizations provide useful and largely dependably delivered information to their information consumers. Both of these quadrants had averages above 5.0. But the information was not sound or usable. The usable information quadrant was the lowest, and the sound information quadrant was also below average. These results captured a common complaint of information consumers, which we summarize as "What we have, we use if we can. But we know it's no good." The information had low soundness because it was not error-free and complete, or concisely and consistently represented. The information had low usability because it was difficult to access and manipulate, and was not believable or of high reputation. This low value for soundness appears to be counter intuitive. Soundness is the most "concrete" quadrant and the lack of information soundness is highly visible. This gap between the actual and expected IQ created an overall low value of perceived information soundness.

This application of the product service performance model to three firms suggests the potential for using this model with our survey instrument to benchmark IQ in organizations. For these three firms, the measurements provided a baseline for assessing IQ improvements, such as installing new computer systems, and undertaking IQ training with information producers.

Discussion of PSP/IQ Model Applications

Our field experience in applying this model suggests many organizations focus primarily on the soundness quadrant (information as a product that conforms to specification). This is consistent with the literature and the reality that IQ is largely the responsibility of the information systems and technology department. Compared to the other quadrants, the soundness aspect of IQ is well-defined. The IT department can establish specifications, in consultation with information consumers, on what information to store in databases, how that information should be represented, and how accurate and complete it should be. The IT department can then monitor the processes employed to collect, store, and maintain this database to ensure conformance to these information product specifications. Furthermore, commercial methods, tools, and techniques to ensure information conforms to specification are becoming readily available. For example, most relational database systems implement integrity rules covering many aspects of information soundness. Add-on tools provide

additional support for analyzing and improving the quality of information in relational databases. The ability of these tools to improve IQ is dependent on their proper application by the IT department. These tools cannot overcome the poor collection integrity rules from information consumers or their incorrect transformation to integrity constraints during database definition.

While sound information is important, it is also important to deliver high-quality information in the dependability, usefulness, and usability quadrants. To deliver dependable information, IT departments must take a service orientation, focusing on the processes of delivering timely and secure information services to consumers. Organizations are also developing expertise in delivering useful information. In general, delivering high quality in the second column in the model, labeled meeting or exceeding consumer expectations, is challenging because consumer expectations are more difficult to define and less stable than product and service quality specifications in the soundness and dependability quadrants. Consumer expectations change over time, as tasks change and general expectations of computing capabilities and services rise.

In the usability quadrant, IT departments are achieving success in providing easy-to-use information access tools to information consumers. IT needs to select and properly support database management systems, end-user interfaces and relevant tools that empower consumers. Ultimately, an IQ management effort must provide actual benefits to consumers. The usability quadrant must be monitored to ensure information is consistently delivered to the consumer. Such an approach is consistent with the continual improvement component of TQM-the uncharted waters of high quality information product and service delivery.

Our research suggests delivering useful and usable information can no longer solely be the responsibility of the IT department a partnership between information consumers, producers, and custodians must be established. We have proposed the concept of an Information Product Manager (IPM) [10]. An IPM serves a role similar to the product or brand manager role in consumer products companies, and is responsible for coordinating the IQ management activities of the IT department and information producers to meet the needs of information consumers. The IPM also monitors the changing needs of information consumers so quality improvement efforts serve to meet the rising expectations of information consumers. Organizations such as Chicago, Illinois-based Information Resources Incorporated (IRI), a provider of scanner-based solution services to the consumer packaged goods industry, are establishing an IPM role to ensure their information products and services meet consumer expectations [4].

The usefulness and usability quadrants are the ultimate goal of the IPM in coordinating all information producers, maintainers, and consumers. Achieving this goal requires sound and dependable information. As our case study indicates, organizations have yet to reach this goal. More research and practical experience is needed so organizations can routinely deliver high-quality information products and services. Few, if any organizations can consistently deliver in all four quadrants.

Conclusion

The four quadrants in our PSP/IQ model-sound, dependable, useful, and usable information-provide a basis for assessing how well organizations develop sound and useful information products and deliver dependable and usable information services

to information consumers. Such an assessment provides a baseline for determining what improvements should be made. It also provides a way to compare information quality across organizations, and to develop IQ benchmarks. Coordination among information producers, custodians, and consumers is essential for delivering quality information as a product and service. An Information Product Manager can help establish and maintain the necessary coordination.

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