Knowledge quality: A review and a revised conceptual model

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Abstract
This paper presents the theoretical underpinnings and measures employed in the assessment of knowledge quality. It aims to identify a conceptual and operational measure of knowledge quality within the context of an e-learning environment. The review is conducted in two phases. First, the conceptual and operational measures of knowledge quality are explained based on the epistemic concept of the essence of knowledge and the knowledge hierarchy structure. Next, a detailed analysis of the dimensions measuring data quality (DQ), information quality (IQ), and knowledge quality (KQ) in 33 studies ranging from research on information systems (IS), to knowledge and information management, e-learning, and data warehouses is presented. Minimal biased methods were used to acquire the literature for this review. The findings reveal that there is an evident lack of research in measuring KQ based on a definite conceptual understanding of the hierarchical structure of knowledge. Furthermore, researchers’ repeated use of the DQ and IQ dimensions to measure KQ has failed to develop a reliable KQ measure. Subsequently, an operational view of KQ is proposed with six distinct dimensions: Adaptable, Applicable, Expandable, True, Innovative, and Justified. This proposed KQ model that is based on the hierarchical structure of knowledge; it identifies the dimensions distinct to the KQ construct. It may be useful for the conceptualization and measure of KQ in various information environments, including e-learning and IS. The proposed model provides a more explicit way to conceptualize and measure the KQ construct by acknowledging that it is an extension of the IQ construct but with distinct and unique dimensions.

Keywords
data quality, information quality, knowledge quality, knowledge hierarchy, e-learning

Data, information, and knowledge must have separate definitions and measurements of their quality.

Introduction
Where is the knowledge we have lost in information?
T.S. Eliot (2009)

The question above highlights the existing need for quality knowledge. In this technological era, the Internet has enabled any individual with access to the web to put a variety of information online at an unmanageable rate. The computing mantra ‘garbage in, garbage out’ succinctly expresses this problem. It is difficult to identify ‘quality’ information (Stvilia et al., 2008) in the gush of untrustworthy, unjustified, inapplicable information—an issue which highlights the need for quality knowledge. Easier and faster access to information does not ensure quality knowledge gain. Therefore, an evaluation criterion for measuring knowledge quality is the core demand of this new information era as a means of improving the transfer of quality knowledge to other individuals. The primary focus of this paper is the elusive definition of the term Knowledge Quality (KQ). The interchangeable use of the terms
‘Information Quality’ (IQ) and ‘Knowledge Quality’ (KQ) and use of IQ dimensions to measure KQ are clearly observed in various studies (Halawi et al., 2007; Jennex and Olfman, 2006; Liu et al., 2010; Tongchua and Praneetpolgrang, 2008), and this lack of precision is the key problem raised in this study. Despite the prior work on measuring KQ in different domains, KQ remains a vaguely defined concept.

In the educational perspective, quality is a critical issue in general, and a more sensitive one for e-learning environments (Alkhattabi et al., 2011) due to the demand for high-quality learning content. This study addresses the quality of learning, specifically explicit (not tacit) knowledge, in terms of quality knowledge gained from the content available on an online; however, content management in knowledge management systems (KMS) is not within the scope of the investigation. The content may be in unstructured (data) or structured (information) format (Kulkarni et al., 2007), but the users’ concern is about the quality knowledge gain from the available content.

Alkhattabi et al. (2010, 2011) attempted to measure online content quality, but they focused on IQ in e-learning environments. Similarly, Mohammadi and Abrizah’s (2013) quality analysis described problems in the IQ of web-based learning content. Baskarada and Koronios (2013) discussed the definitions of DQ, IQ, KQ, and wisdom considering the wisdom hierarchy; however, they did not identify the required quality dimensions. Although knowledge follows the hierarchy of data and information (Rowley, 2007), it still holds a separate place, according to epistemological belief and the knowledge hierarchy. Distinct dimensions are required to measure KQ. Hence, to measure KQ in general and specifically the KQ of online content in e-learning environments, it is necessary to explore the essence of knowledge and its quality.

To fill in the gap in theory on how to measure KQ, this study aims to accomplish the following three objectives:

- Identify the elusive uses of IQ dimensions to measure KQ.
- Examine the essence of knowledge and its hierarchy.
- Investigate the conceptual and operational measurements of DQ, IQ, and KQ through a review of the literature.

**Methodology**

This study adopts Webster and Watson’s (2002) structured approach to locate and identify relevant articles on KQ. The process was as follows:

- The top leading databases were identified through Google Scholar, encompassing journals in the fields of knowledge, knowledge management, philosophy, IS, information sciences, and logic. The databases consulted for this study are ProQuest®, EBSCOhost, Emerald, IEEE Xplore™, JSTOR Archive, SAGE Journals, ScienceDirect®, SpringerLink, Taylor & Francis Online, and Wiley Online Library. Overall, the articles cited in this study were published in the range of 1921–2012. However, for the comparison of DQ, IQ, and KQ, articles from 1996–2012 were used. The year 1996 was chosen because that was the year Wang and Strong (1996) introduced a new and comprehensive data quality framework, which has been widely cited since.
- The keywords or search terms used to find the articles were as follows: data quality, information quality, information vs. knowledge, knowledge, knowledge quality, essence of knowledge, theory of knowledge, tripartite definition of knowledge, knowledge hierarchy, knowledge quality dimensions, influencing factors for knowledge quality, and antecedents of knowledge quality.
- The criteria used to select articles are listed below:
  - The articles were cited at least once. The number of citations for each article was identified through Google Scholar citation labels.
  - The articles were published in journals indexed in Thomson Reuters Web of Knowledge℠.
  - Article titles and abstracts that reflected content related to KQ were scanned, and if the article seemed related to KQ, a detailed, full text review was performed.

**Conceptualization of knowledge quality**

**Elusive use of the term ‘knowledge quality’**

Bailey and Pearson (1983) confirmed 39 factors as a tool for measuring computer user satisfaction in IS context. Rai et al. (2002) measured IQ by adapting seven items (Accuracy, Information Errors, Exact,
Helpful, Precise, Output Options, and Sufficient) from Bailey and Pearson (1983). Later, Kulkarni et al. (2007) attempted to capture the quality of knowledge in a construct they termed ‘Knowledge Content Quality’. They referred to knowledge as the information that resides in electronic repositories, documents, reports, and lessons learned in any format. They used the two constructs ‘presentation style’ and ‘usefulness’ to measure knowledge content quality and items extracted from Rai et al. (2002), which had been adapted from the Bailey and Pearson (1983) scale measured in IS contexts. Halawi et al. (2007) empirically investigated the success of the KMS and measured KQ by adapting the construct of Bailey and Pearson (1983), and DeLone and McLean (1992).

DeLone and McLean (1992) proposed the IS Success Model (see Figure 1a) by reviewing conceptual and empirical studies and suggested its future research implications. They posited six major dimensions of IS success: system quality, IQ, user satisfaction, individual impact, and organizational impact.

The IS Success Model is adapted by Jennex and Olfman (2002) for their Organization Memory/Knowledge System (OM/KS) Modified IS Success Model (see Figure 1b). To measure IQ, they used three constructs, Linkages, Richness, and KM Strategy and Process. They explained ‘linkages’ as a new user’s intent and comfort to seek more knowledge from any expert. Completeness, accuracy, and currency are the measures to quantify these linkages and information/knowledge. KM Strategy and Process reflects that ‘the knowledge needs of the OM/KS users change over time. KM Strategy is needed to determine what information/knowledge should be in the knowledge base, where it is located, and how it is to be acquired’ (Jennex and Olfman, 2002). The measures to quantify the KM strategy and process are Timelines and Amount of resources.

DeLone and McLean further extended their IS Success Model (1992) as the updated IS Success Model (Delone, 2003) (see Figure 1c). Considering the services of the IS function, they added the service quality construct. Furthermore, they grouped all the impact measures in the IS Success Model into a single benefit category called the ‘net benefit’. In the context of e-commerce, they postulated Completeness, Ease of Understanding, Personalization, Relevance, and Security to measure the IQ of content. The author here explains the extension of the IS Success Model and the constructs used by Jennex and Olfman (2002) to measure IQ due to its link with their next model.

Jennex and Olfman (2006) proposed the Knowledge Management Success Model based on Delone’s (2003) widely cited updated IS Success Model. In this KM Success Model (see Figure 1d), the variable IQ is renamed as KQ. They argue, ‘since the KM Success Model is assessing the use of organizational knowledge, the Information Quality dimension is renamed the Knowledge Quality dimension’ (Jennex and Olfman, 2006: 39). The same IQ constructs, i.e. linkages, richness, and knowledge strategy and process, are used for measuring KQ. Using the same dimensions for two different constructs is not justifiable, except by renaming the terms according to different perspectives. Jennex and Olfman (2002) made no attempt to distinguish between knowledge and information.

McKinney et al. (2002) proposed the model of Expectation-Disconfirmation Effects on Web-Customer

![Figure 1a. IS Success Model Source: (DeLone and McLean, 1992).](image-url)
Satisfaction and measured website quality by accessing IQ and system quality. They used Perceived Usefulness, Relevance, Reliability, Scope and Timeliness to measure web-information quality. Later, Chiu et al. (2006) and Liu et al. (2010) investigated knowledge sharing in virtual communities and libraries, and measured KQ by adopting the IQ construct from Delone (2003) and McKinney et al.’s (2002) IQ constructs, validated within the IS domain, are modified by later researchers in the KM domain to measure KQ (Chiu et al., 2006; Halawi et al., 2007; Jennex and Olfman, 2006; Kulkarni et al., 2007; Liu et al., 2010). However, it is not justifiable to measure KQ by neglecting the essence of knowledge, which has roots in epistemological beliefs and applicableness.

Figure 1b. OM/KS Modified IS Success Model Source: (Jennex and Olfman, 2002).

Figure 1c. Updated D&M IS Success Model Source: (Delone, 2003).
Table 1 summarizes the studies that adapt Bailey and Pearson’s (1983) and Delone’s (2003), and McKinney et al.’s (2002) work to measure KQ in different domains.

Comparison of data, information, and knowledge quality dimensions

Repeated use of the same dimensions to measure DQ, IQ, and KQ is evident in various studies. Table 2 summarizes the dimensions several researchers used to measure DQ, IQ, and KQ in 1996–2012.

A comparative matrix was drawn considering the hierarchical structure of DQ, IQ, and KQ. Twenty-three quality dimensions were identified based on an analysis of the mentioned frameworks. All the identified dimensions were compared based on their use in measuring DQ, IQ, and KQ. This matrix helps in identifying and elaborating the following:

1. Operational measurement of DQ, IQ, and KQ
2. Similarity among dimensions used for DQ, IQ, and KQ.

The critique

The discussion above shows that previous researchers have used the modified version of either Wang and Strong’s (1996) DQD or Delone’s (2003) IQD to measure KQ (Chiu et al., 2006; Halawi et al., 2007; Jennex and Olfman, 2006; Liu et al., 2010; Rao and Osei-Bryson, 2007). The DQ dimensions, which are Access Security, Accessibility, Accuracy, Appropriate Amount of Data, Believability, Completeness, Conciseness, Consistency, Current, Interpretability, Level of Detail, Objectivity, Relevancy, Reliability, Representation Consistency, Reputation, Timeliness, Understandability, Usefulness, and Value Added, are adapted for measuring IQ by introducing two further dimensions, i.e. Updated and Verifiability. Herrera-Viedma et al. (2006) and Roca et al. (2006) considered the measure ‘Updated’ due to the demand for up-to-date information on websites and e-learning environments. Stvilia et al. (2008) used the measure ‘Verifiability’ because it is important for verification purposes, for example, when evaluating the IQ of Wikipedia content. However, the KQ construct has faced serious negligence; none of the researchers proposed any new dimensions for measuring it. Also, the ‘Verifiability’ dimension identified in the IQ domain (Stvilia et al., 2008) is not incorporated in later studies to measure KQ. This shows the unmet need for a measure of KQ. To fill in this gap, it is first necessary to understand the essence of knowledge and its quality dimensions. Hence, this study builds on the theory of knowledge and adopts the knowledge hierarchical view to present the comparison of DQD, IQD, and KQ dimensions (KQD) used in the literature for measuring DQ, IQ and KQ, as depicted in the KQ pyramid (see Figure 2).
Table 1. Elusive use of the information quality items for knowledge quality in different domains.

<table>
<thead>
<tr>
<th>Item Extraction From IQ Domain</th>
<th>Adapted By</th>
<th>KQ Domain of Measure</th>
<th>Sample</th>
<th>Item Used</th>
<th>Methodology</th>
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<td>Bailey and Pearson (1983)</td>
<td>Kulkarni et al. (2007)</td>
<td>Validating the KM Success Model</td>
<td>150 midlevel managers enrolled in executive &amp; part-time MBA</td>
<td>Presentation format and Usefulness of the content</td>
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<td>Halawi et al. (2007)</td>
<td>Investigating the KMS Success</td>
<td>99 members from Companies</td>
<td>Convenience of Access, Accuracy, Timeliness, Precision, Reliability, Currency, Completeness, Language, Volume of Output, Relevancy, and Error Recovery</td>
<td>EFA</td>
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<td>McKinney et al. (2002)</td>
<td>Chiu et al. (2006)</td>
<td>knowledge sharing in virtual communities</td>
<td>310 member from virtual community</td>
<td>Relevance, Ease of Understanding, Accuracy, Completeness, Reliability, and Timeliness</td>
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<td>Liu et al. (2010)</td>
<td>knowledge sharing in Libraries</td>
<td>204 professional librarians</td>
<td>Relevance, Ease of Understanding, Accuracy, Completeness, Reliability, and Timeliness knowledge strategy/process, richness, and linkages between knowledge components</td>
<td>SEM</td>
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### Table 2. DQ, IQ, KQ comparison matrix.

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<tr>
<th>Citations in Relevant Area</th>
<th>Accuracy</th>
<th>Believability</th>
<th>Consistency</th>
<th>Objectivity/Unbiased</th>
<th>Reliability</th>
<th>Reputation</th>
<th>Updated</th>
<th>Useful</th>
<th>Appropriate amount of data</th>
<th>Completeness</th>
<th>Level of Detail</th>
<th>Relevancy</th>
<th>Timelessness</th>
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<th>Verifiability</th>
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<th>Interconnectivity</th>
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*eL: e-learning.*
Conceptualization and operational measurement of knowledge quality

Essence of knowledge

Multifaceted knowledge has multi-layered meanings. The epistemological belief discusses the theory of knowledge, which argues that knowledge must encompass ‘justified, true belief’, the three essential attributes of knowledge (Lehrer and Paxson Jr, 1969; Plato, 1967). Collectively, these attributes meet the essence and quality of knowledge. Knowledge hierarchy is the chain, which functionally relates the data, information, and knowledge. These terms hold separate dimensions at each stage that collectively lead to knowledge starting from the data (Braganza, 2004; Brodie and Brodie, 2009; Rowley, 2007).

According to the traditional epistemological belief, it is difficult to assign a single, simple definition to knowledge. However, Plato’s famous tripartite definition of knowledge (Plato, 1967) is widely acknowledged. This tripartite definition considers the Justified True Belief (JTB) as a set of indispensable conditions to fulfil the essence of knowledge (Lehrer and Paxson Jr, 1969; Nonaka, 1994; Plato, 1967; Sosa, 1969; Steup, 2006). To date, sufficient researchers have used this definition as a working model (Artemov and Nogina, 2005; Dancy, 1991; Moser, 2010). The tripartite definition explains that if a person believes in something (p) and justifies it (p), and it (p) is true, then the person knows it; or else the person does not know (Lacewing, 2009). P is a hypothetical term used to refer to an object, person, system, or environment. This account of knowledge was also considered by Plato (Plato, 1967: 201c–202d): ‘Knowledge was true opinion accompanied by reason’. The tripartite definition is only applicable to propositional knowledge (Dancy, 1991; Lacewing, 2009; Lehrer and Paxson Jr, 1969; Moser, 1987; Moser, 2010; Nonaka, 1994; Thalberg, 1969) – it means considering knowing that (p), instead of knowing how or knowing someone (Dancy, 1991).

In brief, propositional knowledge is JTB. The necessary three joined conditions of propositional knowledge are explained as follows: (i) Anyone who knows that p believes that p is the requirement of a belief condition; (ii) the requirement of the truth condition is that any known proposition should be true; and (iii) the requirement of the justification condition is that any known proposition should be sufficiently justified and evidentially supported (Moser, 1987; Moser, 2010).

The history of traditional epistemological beliefs has undergone a critical and never-ending debate to find the meaning of knowledge (Coffman, 2010; Gettier, 1963; Lehrer and Paxson Jr, 1969). The account of knowledge considers ‘truthfulness’ as the essential attribute of knowledge; however, the ‘justification’ of that truthfulness (a truth a person claims to know) (Lehrer and Paxson Jr., 1969; Lehrer, 1990; Lehrer, 2008) has also received much attention. The JTB convergence is based on the justification and truthfulness of the concept. Justification determines to what extent knowledge is truly worthwhile. In this regard, without going into the debate of the nature of truth, it is assumed that justification determines KQ. Without breaking the consistency of traditional epistemological beliefs, this study adopts the conventional definition of knowledge as JTB.

Apart from the epistemological nature of knowledge, the innovativeness of knowledge acquired from listed or published sources in terms of its newness and novelty shows the quality of that knowledge. Innovativeness is considered the key antecedent to achieve KQ (Soo et al., 2004). Knowledge that is new, innovative, and useful for the organization/institution/system fulfils the requirements of quality knowledge (Chan et al., 2008).

‘Knowledge is about action and must be used to some end’ (Nonaka and Takeuchi, 1995; Yoo et al., 2011: 331). As Chekhov (1860–1904) wrote, “Knowledge is of no value unless you put it into practice”. Knowledge which is idle is not worthy at all. The famous philosopher Gibran (1883–1931) said, “A little knowledge that acts is worth infinitely more than much knowledge that is idle”, a concept used by Calabrese and Orlando (2006) in the study of KMS.

Figure 2. Knowledge Quality Pyramid (KQP).
Knowledge hierarchy: roots in data and information

Data, information, and knowledge follow a hierarchical structure based on certain aspects such as belief, understanding, and experience (Nonaka, 1994; Yoo et al., 2011). This hierarchical structure is known as ‘knowledge hierarchy’ or the ‘knowledge pyramid’ and is acknowledged as the fundamental model in information and management literature. The hierarchical structure and its associated quality dimensions are acknowledged in the literature (Melkas, 2004; Pierce et al., 2006; Uotila and Melkas, 2007).

The hierarchical structure is used to describe the functional relationship between data, information, and knowledge. Data as the base point transform into information and successively lead to knowledge (Brodie and Brodie, 2009). The hierarchy has its roots in requirement identification, and users and IT experts distil data from these requirements. The data are processed at the second stage to provide useful information, which subsequently leads to knowledge after distilling (Braganza, 2004). A number of representation styles of this hierarchy are proposed in the literature, including the chain or continuum (Brodie and Brodie, 2009). The two most widely adopted knowledge hierarchy representation styles are the ‘knowledge pyramid’ style (Braganza, 2004) and linear chain style (Rowley, 2007), presented in Figures 3a and 3b respectively.

This study acknowledges the knowledge hierarchy and uses the sequence of knowledge hierarchical structures to help identify the linkages between data, information, and knowledge and distinguish the dimensions required to measure DQ, IQ, and KQ at each stage in the e-learning context.

Knowledge is perceived as the most desirable stage in the implied hierarchical structure of data, information, and knowledge. Information is an organized form of data or meanings that can contribute to structuring knowledge and holds added experience, context, and insight (Machlup, 1983; Mingers, 2008). Justified and believed information has the ability to yield knowledge (Dretske, 1981). Previous research has failed to pay adequate attention to the concept of KQ. However, within the past decade, researchers have begun to show an interest in KQ in different fields (Kulkarni et al., 2007; Rao and Osei-Bryson, 2007; Soo et al., 2004). The adoption of Delone’s (2003) and McKinney et al.’s (2002) IQ measures is clearly seen in the literature on KQ. The role of KQ in knowledge management success (Jennex and Olffman, 2006), shared knowledge in virtual communities (Chiu et al., 2006), KMS success (Halawi et al., 2007), and libraries (Liu et al., 2010) can be identified by using Delone’s (2003) IQ measures. Rao and Osei-Bryson (2007) studied KQ from a multidimensional perspective and explained the multidimensional nature of knowledge item quality in KMS. However, the hierarchical nature of knowledge is not discussed in the perspective of measuring quality. Also, there has been no substantial study measuring KQ in e-learning environments or web-based environments in comparison to IQ in e-learning and web-quality (Alkhattabi et al., 2010; Alkhattabi et al., 2011; McKinney et al., 2002).

The knowledge hierarchy demands a functional relationship between previous dimensions and new proposed dimensions at each stage, in order to separate the previous stage from the new one.

Conceptualization of knowledge quality dimensions. The convergence of the three essential attributes of knowledge, ‘Justified True Belief’, is based on the truthfulness or justification of the concepts (Lehrer and Paxson Jr, 1969; Moser, 1987; Plato, 1967). In the organizational perspective, ‘justification’ being an essential attribute, determines to what extent the knowledge available is true and worthwhile for the organization (Nonaka, 1994). This means that the justification proves the quality of knowledge. If a person justifies the truthfulness of a concept or belief, then he has achieved the essence of knowledge. For example,
if a person believes that the world is round and he has enough justifications to prove that his belief is true, then he holds quality knowledge. Hence, according to Nonaka’s (1994) quality perspective, JTB can be used to measure KQ.

When the JTB conditions are applied to e-learning content scenarios, it seems the content uploaded on e-learning portals consists of true/correct information. Students believe such information because enough references from authenticated sources are available to justify its truthfulness. Therefore, the three dimensions (i.e. believable, true, and justified) can be extracted from this scenario to measure KQ in e-learning environments.

Soo et al. (2004: 3) defined KQ as ‘the acquisition of useful and innovative knowledge’. Chan et al. (2008) acknowledged the Soo et al. (2004) usefulness and innovativeness dimensions to measure KQ. Further, they added that knowledge can be innovative or new for the system or organization, but if it is not useful for the organization development or new innovation in the organization, then it does not fulfil the criteria of KQ. Thus, to measure KQ, usefulness and innovativeness may be used as two dimensions. In the e-learning perspective, the content uploaded on e-learning environments, which is new for individual use, provides good KQ.

KQ depends on the actual use of knowledge and its actionable nature (Nonaka and Takeuchi, 1995). Knowledge which is not idle but actionable it holds quality in itself. As Bakr (573–634) wrote, ‘Without knowledge, action is useless and knowledge without action is futile.’ Knowledge is considered high quality if it is repeatedly used for the formation of other new knowledge (Rao and Osei-Bryson, 2007). This will assure the usefulness of knowledge in a particular domain. Knowledge which is used frequently shows its quality in terms of its adaptability, expandability, and applicability. Nonaka and Takeuchi (1995) and Yoo et al. (2011) acknowledged applicability, adaptability, and expandability as important features of quality knowledge. Knowledge which cannot be applied by individuals in real life for their practical use is not quality knowledge.

In the e-learning context, content that can be modified, applied, and expanded for different class discussions, projects, and presentations on various topics/contexts shows quality and leads to subsequent knowledge gain. Hence, the three dimensions, i.e. expandable, adaptable, and applicable, can be used to measure the quality of knowledge in an e-learning environment.

Operationalization of knowledge quality dimensions. In the quest to find the dimensions of KQ, the author identifies the dimensions that need to be incorporated into the KQ construct. The conceptualization of KQ dimensions can aid in filling in the gap in the current literature on KQP (Figure 4). The conceptual background, as discussed previously, supports the incorporation of six new dimensions into the KQ construct. Focusing on the knowledge hierarchy or knowledge pyramid, the author proposes an operational view of the KQ pyramid that combines the identified dimensions from each stage (DQ, IQ, and KQ) into composite KQ dimensions (see Figure 4) with the following six new dimensions: Adaptable, Applicable, Expandable, True, Innovative, and Justified.

The operational view proposes that the following dimensions can be considered together to measure KQ: Access Security, Accessibility, Accuracy, Appropriate Amount of Data, Believability, Completeness, Conciseness, Consistency, Current, Interpretability, Level of Detail, Objectivity, Relevancy, Reliability, Representation Consistency, Reputation, Timeliness, Understandability, Usefulness, and Value Added’ (DQ dimensions); Updated and Verifiability (IQ dimensions); Adaptable, Applicable Expandable, True, Innovative, and Justified (KQ dimensions). In brief, all of the above dimensions can be considered the set of KQ dimensions.

It is appropriate to use some of the DQ and IQ dimensions for measuring KQ (Rao and Osei-Bryson, 2007; Yoo, 2012; Yoo et al., 2011), as supported by the knowledge hierarchical structure. However, it is not reasonable to adopt all the dimensions. Nonaka (1994)
explained this hierarchical link as follows: ‘Information is a flow of messages, while knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder.’ This understanding emphasizes an essential aspect of knowledge that is related to human action. The operational view of KQ shows that DQ dimensions are adopted in the IQ construct with two distinct dimensions, and the IQ dimensions, along with DQ dimensions, are adopted in the KQ construct with six distinct dimensions. The new six dimensions are based on the conceptual framework of the KQ pyramid.

**Conclusion**

This paper presents a conceptual and theoretical discussion of the KQ construct and a critical review of its operational measurement. Though the KQ concept largely adheres to the knowledge hierarchy, the review reveals a consistent, continuous use of the same dimensions for all three quality measures of data, information, and knowledge. Just as data, information, and knowledge are separate constructs, each with their own definition, so must they have separate definitions and measurements of their quality. For example, information and knowledge differ distinctly. The constructs are three different streams in hierarchical order that need to be measured according to the hierarchy.

The dimensions Access, Security, Accessibility, Accuracy, Appropriate Amount of Data, Believability, Completeness, Concision, Consistency, Current, Interpretability, Level of Detail, Objectivity/Unbiased, Relevancy, Reliability, Representation Consistency, Reputation, Timeliness, Understandability, Usefulness, and Value Added are redundantly used for measuring DQ. Researchers have subsequently adopted all the previous DQ dimensions with the inclusion of two distinct dimensions, i.e. Updated and Verifiability, to measure IQ. However, to measure KQ, no new dimensions have been proposed. Given the traditional epistemological beliefs explained in the theory of knowledge (Artemov and Nogina, 2005; Lehrer and Paxson Jr, 1969; Lehrer, 2008) and knowledge hierarchical view, the continued use of DQ dimensions (Wang and Strong, 1996) and IQ dimensions (Delone, 2003) for measuring KQ is not appropriate.

This review identifies six new dimensions that are uniquely associated with KQ: Adaptable, Applicable, Expandable, True, Innovative, and Justified. The operational view of KQ depicts all the 23 dimensions identified in the literature related to each stage of the pyramid. Apart from the varied use of KQ measures in IS and data warehouse studies, there is clearly a lack of focus on KQ in the e-learning environment. The review of the previous studies revealed that no prominent studies have measured KQ in the e-learning environment. Alkhattabi et al. (2010, 2011) measured IQ in the e-learning environment but neglected KQ. Recently, researchers have sought to measure the quality of information available on online learning portals, either in educational institutions or private organizations; however, KQ, which is the final goal of any learning process, is not discussed.

Consequently, this review suggests future considerations for the study of KQ. Firstly, the operationalized KQ dimensions, which have only theoretical roots, need to be empirically tested to confirm their validity. Secondly, it is necessary to create a comprehensive model for measuring e-learning KQ with relevant categorization and generalization to different domains. The model should lead to the construction of a KQ scale in which each dimension may assess the quality of knowledge separately through specific items. Future research in these directions will be helpful to identify the quality of knowledge in e-learning environments and, subsequently, user satisfaction.

**Figure 4. Operational View of KQ.**

Complex KQ Dimensions

- Access
- Security
- Accessibility
- Accuracy
- Adaptable
- Applicable
- Appropriate amount of data
- Believability
- Completeness
- Concision
- Consistency
- Current
- Interpretability
- Level of Detail
- Objectivity
- Relevancy
- Reliability
- Representation Consistency
- Reputation
- Timeliness
- Understandability
- Usefulness
- Value Added

DQD
- Access
- Security
- Accessibility
- Accuracy
- Appropriate amount of data
- Believability
- Completeness
- Concision
- Consistency
- Current
- Interpretability
- Level of Detail
- Objectivity
- Relevancy
- Reliability
- Representation Consistency
- Reputation
- Timeliness
- Understandability
- Usefulness
- Value Added

IQD
- Adaptable
- Applicable
- Expandable
- True
- Innovative
- Justified
- Updated
- Verifiability

KQD
- Updated
- Value Added
References


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