QUALITY MODEL FOR SEMANTIC IS STANDARDS

Erwin Folmer

University of Twente, TNO, Netherlands Open in Connection

erwin.folmer@tno.nl

Abstract

Semantic IS (Information Systems) standards are essential for achieving interoperability between organizations. However a recent survey suggests that not the full benefits of standards are achieved, due to the quality issues. This paper presents a quality model for semantic IS standards, that should support standards development organizations in assessing the quality of their standards. Although intended for semantic IS standards the potential use of this quality model is much broader and might be applicable to all kind of standards.

Keywords: Quality, Standards, Semantic, Interoperability.

Introduction

As early as 1993, a number of businesses and governments alike were aware of the importance of standards for ensuring interoperability (Rada, 1993) in the area of information systems. Today, in an increasingly interconnected world, interoperability is more important than ever, and interoperability problems are very costly. Studies of the US automobile sector, for example, estimate that insufficient interoperability in the supply chain adds at least $1 billion in additional operating costs, of which 86% is attributable to data exchange problems (Brunnermeier & Martin, 2002). The adoption of standards to improve interoperability in the automotive, aerospace, shipbuilding and other sectors could save billions (Gallaher, O'Conner, & Phelps, 2002). Although interoperability standards have been created for a range of industries (Zhao, Xia, & Shaw, 2005), problems persist, suggesting a lack of quality of the standards themselves, and the processes by which they are developed. In 2009, the European Commission recognized the importance of quality of standards and set a policy to "increase the quality, coherence and consistency of ICT standards" (Commission, 2009). Sherif, Egyedi, and Jakobs (2005) state that their paper on standards' quality was the first to address this topic, albeit only for technical standards. But what about semantic IS standards, that promote communication and coordination among organizations, and may address product identification, data definitions, business document layout, and/or business process sequences (Steinfield, Wigand, Markus, & Minton, 2007)? Even though these semantic IS standards are important in the creation of inter-organizational interoperability and solving data exchange problems, is there a need to measure the quality of semantic IS standards? Regarding semantic IS standards, Markus, Steinfield, Wigand, and Minton (2006) asserts "the success of (…) standards diffusion is affected by the technical content of the developed standard, …". In other words, the quality of a standard is directly correlated to its adoption. Despite the importance of standards in the evolution of information and communication technology (Lyytinen & King, 2006), the issue of semantic IS standard quality is not often addressed (Folmer, Berends, Oude Luttighuis, & Van Hillegersberg, 2009).

In this research the focus is on the quality of semantic IS standards. Quality is being defined as fitness for use, in line with the Juran's definition in the area of product engineering (Juran & Gryna, 1988). This research started with a survey among 34 standard development organizations to question if there is a need for more knowledge regarding quality of semantic IS standards, and in particular the need of an instrument for Quality Measurement of Semantic Standard (iQMSS). The survey results suggest a high need and high potential usage of such an iQMSS (Folmer, Oude Luttighuis, & van Hillegersberg, 2011a). Follow up research covered the design steps based on a design science approach (Hevner, March, Park, & Ram, 2004), including amongst others an extensive state of the art (Folmer & Verhoosel, 2011). This paper presents part of the final research: the Quality Model of Semantic Standards (QMSS).

Research Approach

The design process of the final build QMSS is characterized by experimenting with different builds of the QMSS applied in explorative case studies. These different builds have used different sources from literature, and have yielded in different results. The state of the art, already showed that although a quality instrument for semantic IS standards does not exists, there is tremendous amount of studies to be used in setting up such a quality instrument. Although the state of the art describes many of these studies it has been taken one step further by searching for studies that particularly mention quality attributes or measures related to quality for different kind of artifacts but that might be valid for semantic IS standards as well.

The development started with the quality model developed within the Integrate project (Krukkert & Punter, 2008), which can be seen as the pre-successor of the QMSS, be it the first build. In this first build some studies have been included, mainly from the software domain, but in general it was more practical oriented in the end. Within the next iterations several builds have been constructed by which a growing amount of practical experiences and theoretical studies already has been accounted for. The builds 0.3 and 0.4 have been used for explorative case studies, while build 0.5 was focused on surveying measurable concepts from the data quality domain on relevance for semantic IS standards for inclusion (Folmer & Van Soest, 2011). The first five (0.1 till 0.5) builds of the instrument were all explorative by nature, without having strict version management resulting that build 0.5 is not continuing work of build 0.4, but instead is based on build 0.1. Therefore build 0.6 was constructed as an integration of all previous builds and the fundament for further development. For the final build 0.7, completeness of inclusion of all known sources is important. The next diagram shows all the information sources used in the steps taken during the development of the instrument. Other older studies are often included by more recent studies that build on the older material.

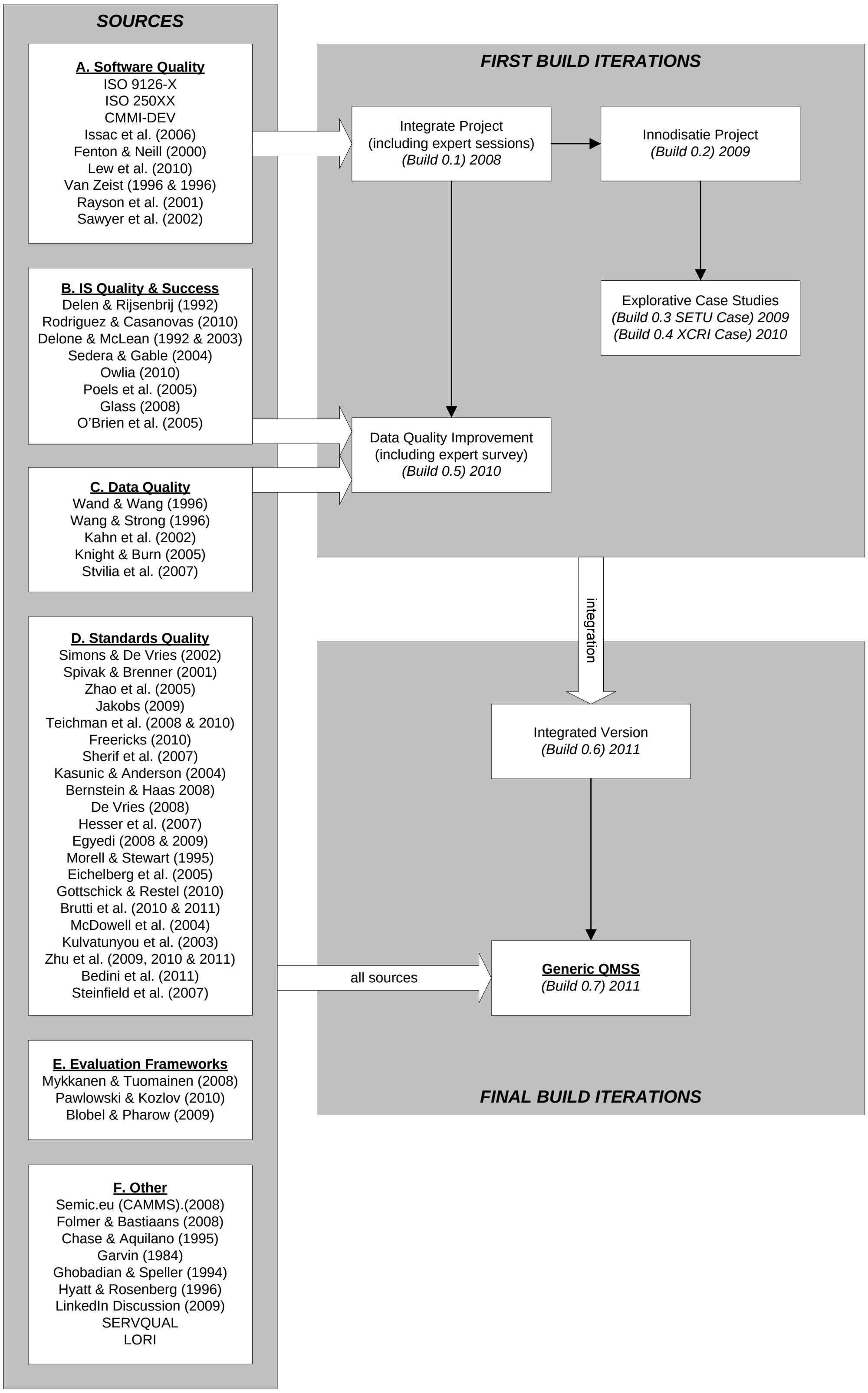

Figure 1 – Overview of sources and builds of QMSS

Final build Research Approach (build 0.7)

This section will describe the research approach of the final build (0.7), as depicted in figure 2. In this approach, measurable concepts (what we want to know) and quality measures (how to measure it) are distinguished. For instance readability might be a measurable concept for a standard, while the quality measure might be the gunning fog index. Finally, to be able to use the QMSS in practice a usage model needs to be constructed.

Starting point for working on the final build was the previous integrated build (version 0.6). The bottom-up approach was continued by following four main steps: A. define the high level structure, B. define the quality model (measurable concepts), C. define the measures (section 3), D. define usage process. These four steps are a work breakdown approach to focus on specific parts of the QMSS. For each of the four main steps the same approach was used: carrying out a circle of steps, to be sure that:

1. Requirements are checked (Folmer, Krukkert, Oude Luttighuis, & Van Hillegersberg, 2010).
2. Experiences from explorative case studies were used.
3. Literature sources were included (see figure 1)
4. Design rules, applicable to many types of IT artifacts, were followed (from (Cavano & McCall, 1978; Gregor, 2006; Morell & Stewart, 1995).
5. Finally, the outcome has to be written down according to the chosen terminology (e.g. measurable concepts, information needs, attributes, measures), according to the terminology of the SMO (Garcia et al., 2009).

The combination of these steps makes it possible that quality attributes for the software domain (as example) are checked on relevance to semantic IS standards (the requirements), and are aggregated and described according to design rules and the quality language that have been selected for the QMSS.

Additionally, one main step has been added, when it became apparent that there was a lack of measures in our literature sources (step C), an expert workgroup was set up to be able to gather measures from experts instead of literature. However, this workgroup session was also used as review for the measurable concepts of the quality model.

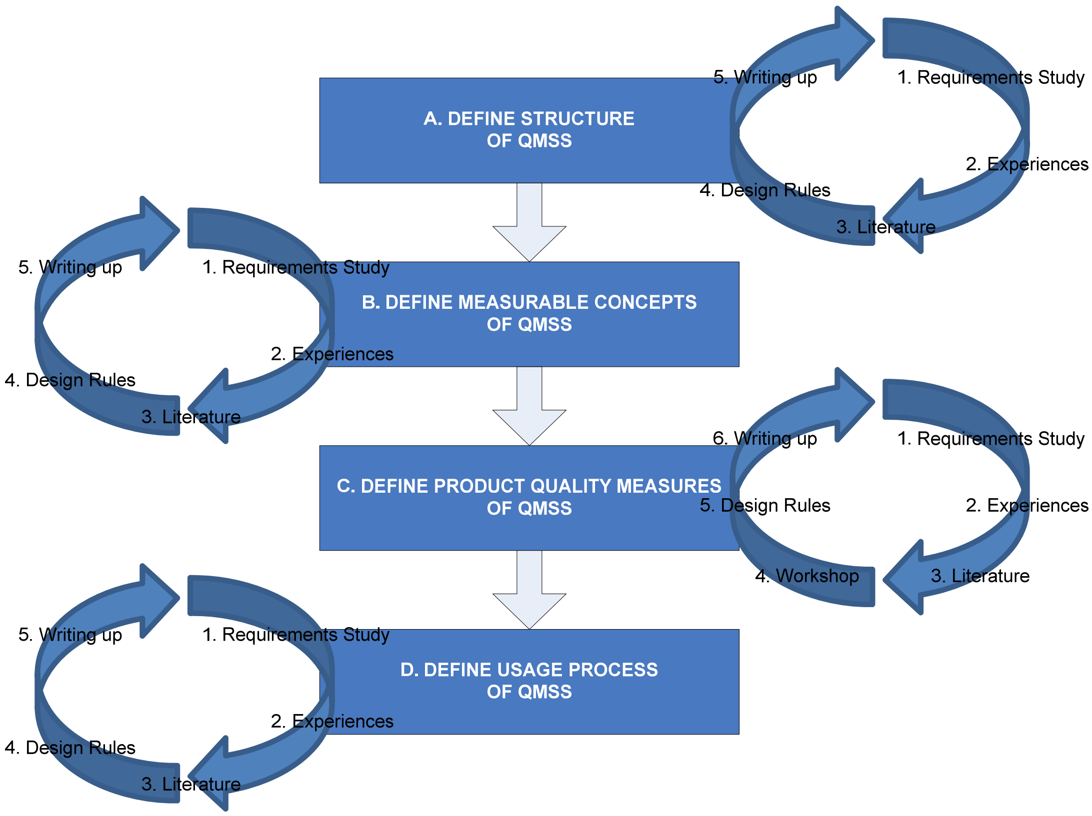

Figure 2 – Research approach for final build

The Quality Model for Semantic IS Standards

A flexible structure is part of the requirements, while the design rules talk about a logical structure. Within the explorative case studies the different builds of the QMSS grew in number of quality measures and often the added measures were not strictly related to internal quality. Based on these three findings, the logical structure was developed, that makes the instrument flexible to use.

The original information need for the research scope was related to the intrinsic quality of the standard. Based on the requirements study and experience during the explorative case studies other information needs became apparent, amongst others:

1. The internal quality of the standard? – the original information need
2. The implementability of the standard?
3. The durability (future-proofness) of the standard?
4. Should I select the standard?
5. Is the standard a good solution for the interoperability problem?

Looking at a broader view, it is noticable that separations of concerns are often made. For instance the distinction between the product and the process as proposed by many (e.g. (Morell & Stewart, 1995; Stvilia, Gasser, Twidale, & Smith, 2007)). According to them two types of metrics are important (Morell & Stewart, 1995):

- Monitor the progress of the process = process metrics
- Quality of the standard (outcome) = product metrics

Other research showed that relevant concepts for the semantic IS standard include its context, content, development organization, and its application (Folmer, Oude Luttighuis, & Van Hillegersberg, 2011b). This also reflects the ISO 9126 and 25000 family of standards for software engineering, that includes separation of concerns based on the product (internal and external), the process and its use (Figure 3).

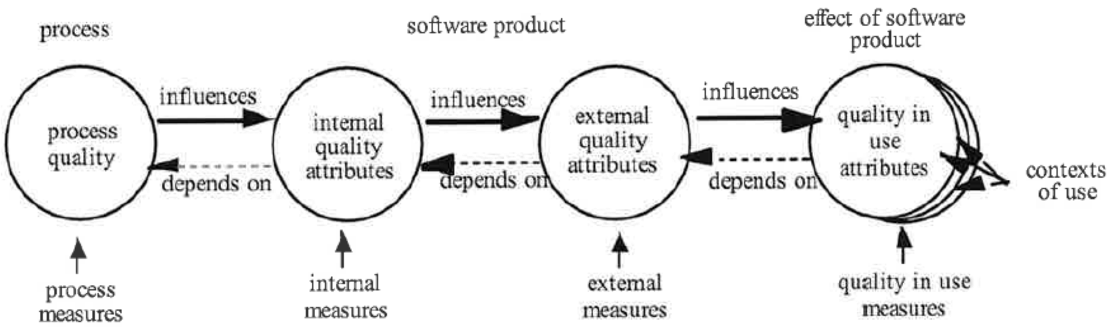

Figure 3 - ISO Quality Model for Software

The result of applying this separation of concerns to the quality model is a separation in three parts: product quality, process quality, and the quality in practice. This maps to the conceptual model of a semantic IS standard since product quality deals with the content (the specification), the process quality relates to the development & maintenance processes as carried out by the development organization, whereas quality in practice deals with the application environment, the performance of the implementations of the standard.

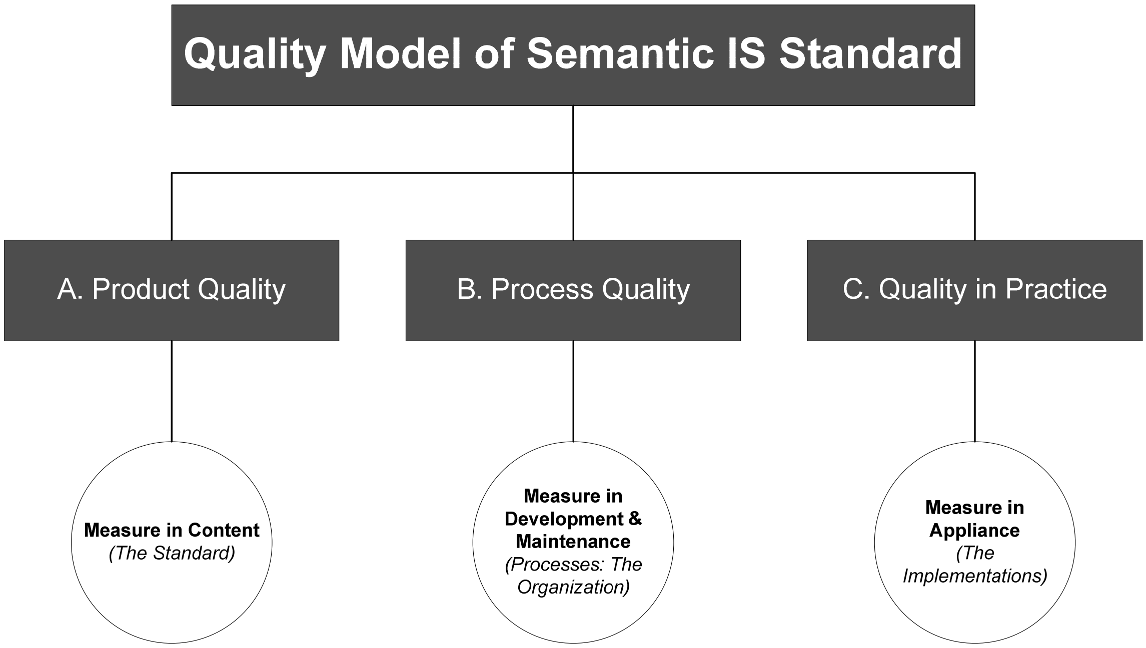

Figure 4 - Structure of Quality Model

This structure makes the use of the quality model more flexible. Dependent on the information need only parts of the quality model have to be used. The information needs map to the three parts accordingly:

1. The internal quality of the standard? – Part A

2. The implementability of the standard? – Part A+ B

3. The durability (future-proofness) of the standard? – Part B + A (partly)

4. Should I select the standard? – Mainly part C

5. Is the standard a good solution for the interoperability problem? – All parts

The focus throughout this research project is on the internal, product quality of the standard. This model shows the boundaries and context of product quality, and although we set up models for each of the three qualities, the product quality model is most mature and will be presented in the remainder of this paper.

Product Quality

Based on the research approach the model for product quality has been constructed. The product quality basically consists of three information needs:

1. Is the functionality of the standard appropriate? – Does it have the features to solve the interoperability problem?

2. Is the standard usable? – Can the standard be implemented and used without burden?

3. Is the standard durable? - Will the standard be future-proof?

These three information needs define the structure within the model.

For the technical complexity the measurable concepts, and later on the measures, are focusing on XML technology. When other technology is used, the model should be changed accordingly, including the measures. That latter might be quite difficult, because XML metrics are often studied because of its commodity. The model for product quality, as output from the research approach described earlier, is depicted within figure 5.

The definitions and some further explanation/remarks are presented in the following table. Due to page restrictions we only included the definitions for the "Functionality" branch (left side). If a source for the definition is mentioned than it should be read as "originated from", but the actual definition might be deferred.

Conclusions and Further Research

This paper presented the product quality part of the QMSS, which in itself is part of the instrument (iQMSS). Other parts include a complete set of measures to apply the quality model in practice to measure the quality of a standard, just as a cookbook on how to use the instrument.

The next steps are related to validation. We have planned a follow up to the problem survey to question if this instrument contributes to the needs expressed in the problem survey. Although the first results seem positive, we need more validation research to be sure. In the end it has to guide standards developers in improving the quality of standard that will lead to better interoperability in practice.

The iQMSS is particularly developed for semantic IS standards, an important type of standards for achieving interoperability between organizations, and currently a focal point for many European governments, including the European Union. It is however expected that the quality model can be easily transformed for application of other standard types.

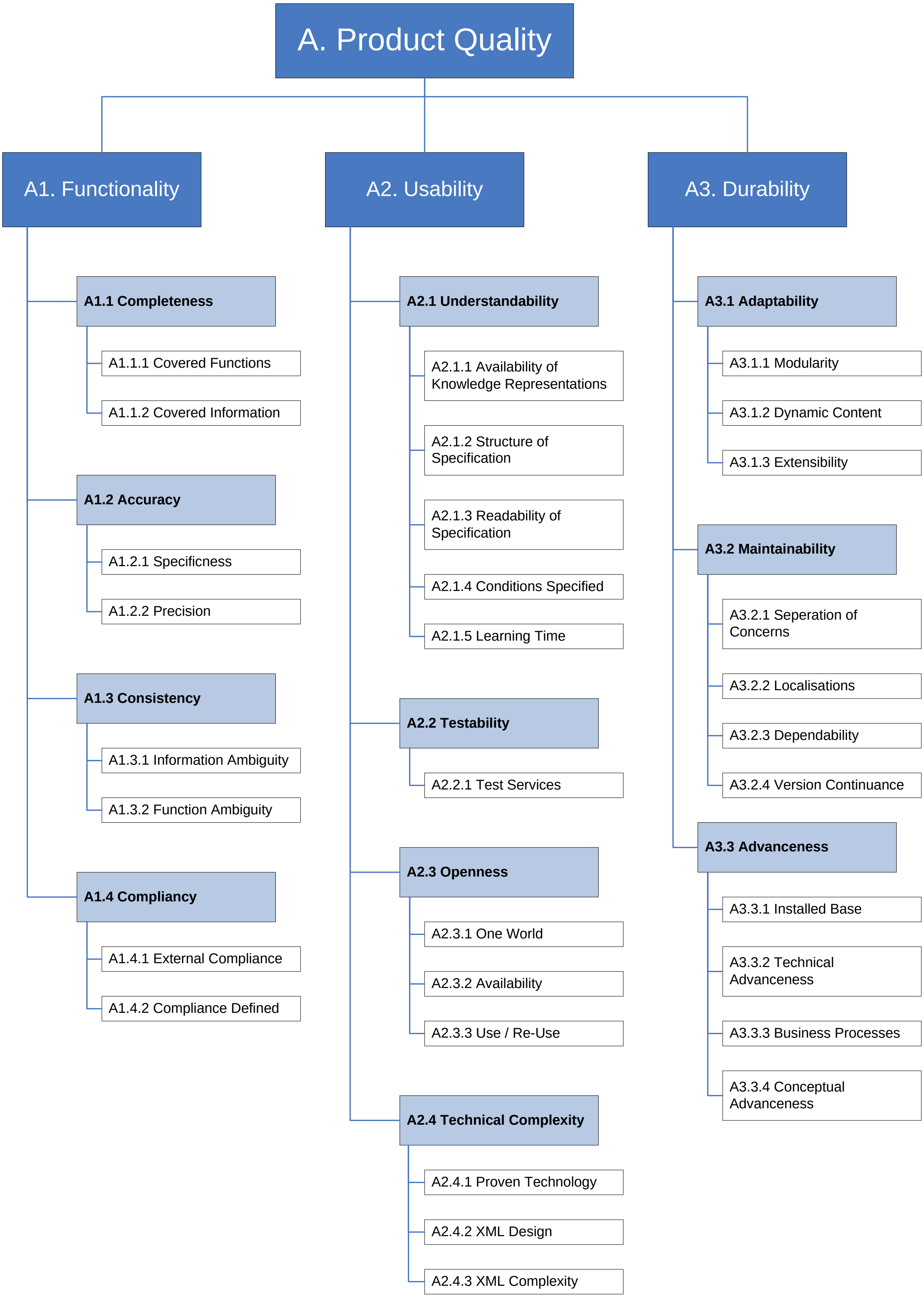

Figure 5 – Model for Product Quality

Measurable Concept	Definition	Remarks
A. Product Quality	The total of attributes of a standard that determines its ability to satisfy stated and implied needs when used under specified conditions (ISO 9126)	This includes both internal and external quality in ISO terms.
A1. Functionality	The capability of the standard to provide functions which meet stated and implied needs when the standard is used under specified conditions. (ISO 9126)	The specification fulfills the functional needs of the intended job.
A1.1 Completeness	The extent to which a standard is of sufficient breadth, depth, and scope for the task at hand. (Wand & Wang, 1996)	This includes other terms like relevancy and suitability, and is the functional view on the content of the specification. The task at hand is aimed at solving an interoperability problem.
A1.1.1 Covered Functions	The level of functions specified in the specification in relation to the interoperability problem.	Indicates if the standard covers all functionality required to solve the interoperability problem.
A1.1.2 Covered Information	The level of information elements specified to support for the interoperability problem	When information elements are missing or when too many information elements have been added, it will negatively impact interoperability.
A1.2 Accuracy	The capability of the standard to provide true data with the needed degree of precision. (ISO 9126 & ISO 25012)	The level of needed specificness and precision of both semantic meaning and technical syntax. (This does not cover, but relates to, the quality of the content: consistency (A1.3))
A1.2.1 Specificness	The level of detail and in-depth of the scope.	Does the standard address a specific problem or a generic problem?
A1.2.2 Precision	The match between the precision requested and provided, unambiguously. (ISO 25012)	Syntactic and semantic accuracy. (For instance *sur*name (instead of name, and not limited to 10 digits).
A1.3 Consistency	The extent of consistency in using the same values (vocabulary control) and elements to convey similar concepts and meaning in a standard. (Stvilia et al., 2007)	The degree of coherence and freedom of contradiction within the standard (ISO 25012). The quality of the content of the different models.
A1.3.1 Information ambiguity	The level of ambiguity of the information elements, and consistency of use.	The quality of the structuring and definition of the information elements.
A1.3.2 Function ambiguity	The level of ambiguity of the function elements and consistency of use.	The quality of the structuring and definition of the functions, processes and business rules.
A1.4 Compliancy	The capability of the standard to adhere to other standards, conventions or regulations in laws, but also defining what compliancy implies for this standard. (ISO 9126 & ISO 25012)	How compliancy to other standards is implemented, and how conformance to this standard can be assured.
A1.4.1 External compliance	The compliance level to other standards, conventions, or regulations in laws and similar prescriptions	Compliancy with other standards on two levels: 1. Standards used to create this standard (e.g. UML). 2. Standards on different levels of interoperability (e.g. Laws, or technical standards).
A1.4.2 Compliance defined	The availability of a strict set of testable rules that define compliancy with the standard.	Is there a strict formulation when an implementation is conformant to the standard? This supports strict implementations.

Table 1 – Measurable concepts for product quality defined

References

Bedini, I., Gardarin, G., & Nguyen, B. (2011). Semantic Technologies and E-Business. In E. Kajan (Ed.), *Electronic Business Interoperability: Concepts, Opportunities and Challenges.* (pp. 243-278). Hershey: IGI Global.

Bernstein, P. A., & Haas, L. M. (2008). Information integration in the enterprise. *Communications of the ACM, 51*(9), 72-79.

Blobel, B., & Pharow, P. (2009). Analysis and evaluation of EHR approaches. *Methods Inf Med, 2009*(48), 162-169.

Brunnermeier, S. B., & Martin, S. A. (2002). Interoperability costs in the US automotive supply chain. *Supply Chain Management, 7*(2), 71-82.

Brutti, A., Cerminara, V., D'Agosta, G., Sabbata, P., & Gessa, N. (2010). Use Profile Management for Standard Conformant Customisation. In K. Popplewell, J. Harding, R. Poler & R. Chalmeta (Eds.), *Enterprise Interoperability IV - Making the Internet of the Future for the Future of Enterprise* (pp. 449-459): Springer London.

Brutti, A., De Sabbata, P., Frascella, A., Novelli, C., & Gessa, N. (2011). *Standard for eBusiness in SMEs networks: the increasing role of customization rules and conformance testing tools to achieve interoperability*. Paper presented at the Enterprise Interoperability, proceedings of the Workshops of the Third International IFIP Working Conference IWEI 2011.

Buttle, F. (1996). SERVQUAL; review, critique, research agenda. *European Journal of Marketing, 30*(1), 8-32.

Cavano, J., P., & McCall, J., A. (1978). A framework for the measurement of software quality. *ACM Sigsoft Software Engineering Notes, 3*(5), 133-139.

Chase, R. B., & Aquilano, N., J. (1995). *Production and Operations Management: Manufacturing and Services* (7 ed.). Chicago: Irwin.

De Vries, H. J. (2008). Best Practice in Company Standardization. In K. Jakobs (Ed.), *Standardization Research in Information Technology: New Perspectives* (pp. 27-47). Hershey: Information Science Reference.

Delen, G. P. A. J., & Rijsenbrij, D. B. B. (1992). The specification, engineering, and measurement of information systems quality. *The Journal of Systems and Software, 17*(3), 205-217.

DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3*(1), 60-95.

Delone, W. H., & McLean, E. R. (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of management information systems, 19*(4), 9.

Egyedi, T. M. (2008). An Implementation Perspective on Sources of Incompatibility and Standards' Dynamics In T. M. Egyedi & K. Blind (Eds.), *The Dynamics of Standards* (pp. 28-43). Cheltenham: Edward Elgar.

Egyedi, T. M. (2009). Between Supply and Demand: Coping with the Impact of Standards Change. In K. Jakobs (Ed.), *Information Communication Technology Standardization for E-Business Sectors; Integrating Supply and Demand Factors* (pp. 171-185). Hershey: Information Science Reference.

Eichelberg, M., Aden, T., Riesmeier, J., Dogac, A., & Laleci, G. B. (2005). A survey and analysis of electronic healthcare record standards. *ACM Computing Surveys, 37*(4), 277-315.

European Commission, (2009). *Modernising ICT Standardisation in the EU - The Way Forward.* Retrieved 2010-01-20. from http://ec.europa.eu/enterprise/newsroom/cf/document.cfm?action=display&doc_id=3152&userservice_id=1&request.id=0.

Fenton, N., E. , & Neil, M. (2000). *Software metrics: roadmap*. Paper presented at the Proceedings of the Conference on The Future of Software Engineering.

Fenton, N. E., & Neil, M. (1998). A strategy for improving safety related software engineering standards. *IEEE Transactions on Software Engineering, 24*(11), 1002-1013.

Folmer, E., & Bastiaans, J. (2008). *Quality of Electronic Messaging Standards' Specifications.* Paper presented at the ICE 2008.

Folmer, E., Berends, W., Oude Luttighuis, P., & Van Hillegersberg, J. (2009). *Top IS research on quality of transaction standards, a structured literature review to identify a research gap.* Paper presented at the 6th International Conference on Standardization and Innovation in Information Technology, Tokyo, Japan.

Folmer, E., Krukkert, D., Oude Luttighuis, P., & Van Hillegersberg, J. (2010). *Requirements for a quality measurement instrument for semantic standards.* Paper presented at the 15th EURAS Annual Standardisation Conference, Lausanne.

Folmer, E., Oude Luttighuis, P., & van Hillegersberg, J. (2011a). Do semantic standards lack quality? A survey among 34 semantic standards. *Electronic Markets, 21*(2), 99-111.

Folmer, E., Oude Luttighuis, P., & Van Hillegersberg, J. (2011b). *A Model for Semantic IS Standards*. Paper presented at the 16th EURAS Annual Standardisation Conference.

Folmer, E., & Van Soest, J. (2011). Towards a quality model for Semantic IS Standards. *To be Published*.

Folmer, E., & Verhoosel, J. (2011). *State of the Art on Semantic IS Standardization, Interoperability & Quality*. Enschede: TNO, University of Twente, CTIT, NOiV.

Freericks, C. (2010). *Workable Service Standard Guides Through Meta-Standards.* Paper presented at the 15th EURAS Annual Standardisation Conference "Service Standardization", Lausanne.

Gallaher, M. P., O'Conner, A. C., & Phelps, T. (2002). *Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries* (No. RTI Project Number 07007.016).

Garcia, F., Ruiz, F., Calero, C., Bertoa, M. F., Vallecillo, A., Mora, B., et al. (2009). Effective use of ontologies in software measurement. *The Knowledge Engineering Review, 24*(Special Issue 01), 23-40.

Garvin, D. A. (1984). What Does "Product Quality" Really Mean? *Sloan management review, 26*(1), 24-43.

Ghobadian, A., & Speller, S. (1994). Gurus of quality: a framework for comparison. *Total Quality Management, 5*(3), 53-69.

Glass, R. L. (2008). The notion of an information system Apgar score. *Information Systems Management, 25*(3), 290-291.

Gottschick, J., & Restel, H. (2010, 1-3 Sept. 2010). *An Empirical Evaluation of the Quality of Interoperability Specifications for the Web.* Paper presented at the Software Engineering and Advanced Applications (SEAA), 2010 36th EUROMICRO Conference on.

Gregor, S. (2006). The Nature of Theory in Information Systems. *MIS Quarterly, 30*(3), 611-642.

Hesser, W., Czaya, A., & Riemer, N. (2007). Development of Standards. In W. Hesser (Ed.), *Standardisation in Companies and Markets* (pp. 123-169). Hamburg: Helmut Schmidt University.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly: Management Information Systems, 28*(1), 75-105.

Hyatt, L., & Rosenberg, L. (1996). *A Software Quality Model and Metrics for Identifying Project Risks and Assessing Software Quality.* Paper presented at the Product Assurance Symposium and Software Product Assurance Workshop.

ISO/IEC. (2001). *ISO/IEC 9126-1 Software engineering - Product quality - Part 1: Quality model*.

ISO/IEC. (2003a). *ISO/IEC 9126-2 Software engineering - Product quality - Part 2: External metrics*.

ISO/IEC. (2003b). *ISO/IEC 9126-3 Software engineering - Product quality - Part 3: Internal metrics*.

ISO/IEC. (2004). *ISO/IEC 9126-4 Software engineering - Product quality - Part 4: Quality in use metrics*.

ISO/IEC. (2007). *ISO/IEC 25021 Software engineering - Software product Quality Requirements and Evaluation (SQuaRE) - quality measure elements*.

ISO/IEC. (2008). *ISO/IEC 25012 Software engineering - Software product Quality Requirements and Evaluation (SQuaRE) - Data quality model*.

ISO/IEC. (2011). *ISO/IEC 25010 Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models*.

Issac, G., Rajendran, C., & Anantharaman, R. N. (2006). An instrument for the measurement of customer perceptions of quality management in the software industry: An empirical study in India. *Software Quality Journal, 14*(4), 291-308.

Jakobs, K. (2009). Perceived Relation between ICT Standards' Sources and their Success in the Market. In K. Jakobs (Ed.), *Information Communication Technology Standardization for E-*

Business Sectors; Integrating Supply and Demand Factors (pp. 65-80). Hershey: Information Science Reference.
Juran, J. M., & Gryna, F. M. (Eds.). (1988). *Juran's quality control handbook* (4th edition ed.): McGraw-Hill.
Kahn, B., K. , Strong, D., M. , & Wang, R., Y. . (2002). Information quality benchmarks: product and service performance. *Communications of the Acm, 45*(4), 184-192.
Kasunic, M., & Anderson, W. (2004). *Measuring Systems Interoperability: Challenges and Opportunities*: Carnegie Mellon University.
Knight, S. A., & Burn, J. (2005). Developing a framework for assessing information quality on the World Wide Web. *Informing Science, 8*, 159-172.
Krukkert, D., & Punter, M. (2008). *Kwaliteitsraamwerk voor Standaarden*. Enschede: TNO.
Kulvatunyou, B., Ivezic, N., Martin, M., & Jones, A., T. . (2003). *A business-to-business interoperability testbed: an overview*. Paper presented at the Proceedings of the 5th international conference on Electronic commerce.
Lew, P., Olsina, L., & Zhang, L. (2010). *Quality, Quality in Use, Actual Usability and User Experience as Key Drivers for Web Application Evaluation.* Paper presented at the Web Engineering (ICWE 2010).
Lyytinen, K., & King, J. L. (2006). Standard Making: A Critical Research Frontier for Information Systems Research. *MIS Quarterly, 30*, 405-411.
McDowell, A., Schmidt, C., & Yue, K. B. (2004). *Analysis and metrics of XML schema.* Paper presented at the Proceedings of the International Conference on Software Engineering Research and Practice, SERP'04, Las Vegas, NV.
Morell, J. A., & Stewart, S. L. (1995). A Five-Segment Model for Standardization. In B. Kahin & J. Abbate (Eds.), *Standards Policy for Information Infrastructure* (pp. 198-219). Cambridge: The MIT Press.
Mykkanen, J. A., & Tuomainen, M. P. (2008). An evaluation and selection framework for interoperability standards. *Information and Software Technology, 50*(3), 176-197.
Nentwig, L., Adametz, H., Bittins, S., Gottschick, J., Reichling, K., & Meyer, S. (2008). *Quality Framework for Interoperability Assets*: Semantic Interoperability Centre Europe.
Nyeck, S., Morales, M., Ladhari, R., & Pons, F. (2002). 10 years of service quality measurement: reviewing the use of the SERVQUAL instrument. *Cuadernos de Diffusion, 7*(13), 101-107.
O'Brien, L., Bass, L., & Merson, P. (2005). *Quality Attributes and Service-Oriented Architectures*: Carnegie Mellon University, Software Engineering Institute.
Owlia, M. S. (2010). A framework for quality dimensions of knowledge management systems. *Total Quality Management, 21*(11), 1215-1228.
Pawlowski, J. M., & Kozlov, D. (2010). Analysis and Validation of Learning Technology Models, Standards and Specifications: The Reference Model Analysis Grid (RMAG). *International Journal of IT Standards and Standardization Research, 8*(2), 1-19.
Poels, G., Maes, A., Gailly, F., & Paemeleire, R. (2005). Measuring the Perceived Semantic Quality of Information Models. In J. Akoka, S. Liddle, I.-Y. Song, M. Bertolotto, I. Comyn-Wattiau, S. Si-Said Cherfi, W.-J. Heuvel, B. Thalheim, M. Kolp, P. Bresciani, J. Trujillo, C. Kop & H. Mayr (Eds.), *Perspectives in Conceptual Modeling* (Vol. 3770, pp. 376-385): Springer Berlin / Heidelberg.
Rada, R. (1993). Standards: the language for success. *Communications of the ACM, 36*(12), 17-23.
Rayson, P., Emmet, L., Garside, R., & Sawyer, P. (2001). The REVERE Project: Experiments with the Application of Probabilistic NLP to Systems Engineering. In M. Bouzeghoub, Z. Kedad & E. Métais (Eds.), *Natural Language Processing and Information Systems* (Vol. 1959, pp. 288-300): Springer Berlin / Heidelberg.
Rodriguez, N., & Casanovas, J. (2010). *A structural model of information system quality; an empirical research.* Paper presented at the AMCIS 2010, Lima, Peru.
Sawyer, P., Rayson, P., & Garside, R. (2002). REVERE: Support for Requirements Synthesis from Documents. *Information Systems Frontiers, 4*(3), 343-353.
Sedera, D., & Gable, G. (2004). *A Factor and Structural Equation Analysis of the Enterprise Systems Success Measurement Model.* Paper presented at the ICIS 2004.
Sherif, M. H., Jakobs, K., & Egyedi, T. M. (2007). Standards of quality and quality of standards for Telecommunications and Information Technologies. In M. Hörlesberger, M. El-

nawawi & T. Khalil (Eds.), *Challenges in the Management of New Technologies* (pp. 427-447). Singapore: World Scientific Publishing Company.

Simons, C. A. J., & Vries, H. J., de (2002). *Standaard of Maatwerk, Bedrijfskeuzes tussen uniformiteit en verscheidenheid*. Schoonhoven: Academic Services.

Spivak, S. M., & Brenner, F. C. (2001). *Standardization essentials: principles and practice*. New York [etc.]: Dekker.

Steinfield, C. W., Wigand, R. T., Markus, M. L., & Minton, G. (2007). Promoting e-business through vertical IS standards: lessons from the US home mortgage industry. In S. Greenstein & V. Stango (Eds.), *Standards and Public Policy* (pp. 160-207). Cambridge: Cambridge University Press.

Stvilia, B., Gasser, L., Twidale, M. B., & Smith, L. C. (2007). A framework for information quality assessment. *Journal of the American Society for Information Science and Technology, 58*(12), 1720-1733.

Teichmann, H. (2010). *Effectiveness of Technical Experts in International Standardization.* Paper presented at the 15th EURAS Annual Standardisation Conference "Service Standardization", Lausanne.

Teichmann, H., Vries, H. J., de, & Feilzer, A. (2008). Linguistic Qualities of International Standards. In K. Jakobs (Ed.), *Standardization Research in Information Technology: New Perspectives* (pp. 86-103). Hershey: Information Science Reference.

Van Zeist, B., Hendriks, P., Paulussen, R., & Trienekens, J. (1996). *Kwaliteit van softwareproducten; praktijkervaringen met een kwaliteitsmodel*: Kluwer Bedrijfsinformatie.

Van Zeist, R. H. J., & Hendriks, P. R. H. (1996). Specifying software quality with the extended ISO model. *Software Quality Journal, 5*(4), 273-284.

Wand, Y., & Wang, R. Y. (1996). Anchoring Data Quality Dimensions in Ontological Foundations. *Communications of the Acm, 39*(11), 86-95.

Wang, R. Y., & Strong, D. M. (1996). Beyond Accuracy: What Data Quality Means to Data Consumers. *Journal of Management Information Systems, 12*(4), 5-33.

Zhao, K., Xia, M., & Shaw, M. J. (2005). Vertical e-business standards and standards developing organizations: A conceptual framework. *Electronic Markets, 15*(4), 289-300.

Zhu, H., & Fu, L. (2009). *Towards Quality of Data Standards: Empirical Findings from XBRL.* Paper presented at the ICIS 2009.

Zhu, H., & Wu, H. (2010). *Quality of XBRL US GAAP Taxonomy: Empirical Evaluation using SEC Filings.* Paper presented at the AMCIS 2010, Lima, Peru.

Zhu, H., & Wu, H. (2011). Quality of data standards: framework and illustration using XBRL taxonomy and instances. *Electronic Markets*, 1-11.