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# ASSESSING THE QUALITY OF ONTOLOGY

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## Abstract

*In the Information Sciences an ontology specifies the conceptual structure of a knowledge domain through its vocabulary and its meaning, or semantics. Examples of ontologies include database schemas, taxonomies and library classification schemes. Computer-based ontologies specify a common understanding of a domain both for its different human users and for automated information processes such as interpretation, aggregation, manipulation, etc. As an ontology is fundamental to systems in an organisation and to communication between organisations, its quality is critically important for the sound operation of those systems. But there is a problem in that there seems to be no systematic basis or method for conducting an assessment of the quality of an ontology. There is an abundance of literature proposing ideas about what constitutes a 'good' ontology, but it is diverse, incoherent and untested. This paper reports research which reviewed the literature, extracted some 220 quality criteria, formulated these into an assessment instrument and partially demonstrated the instrument in a case study. The demonstration showed some of the difficulties associated with assessing quality, in particular, the difficulty of grounding the criteria in the actuality of the case and in interpreting the results of an assessment.*

*Keywords: Ontology Quality, Quality Assessment, Ontology Criteria, Standard Business Reporting*

# 1 INTRODUCTION AND THEORETICAL BACKGROUND

The research reported in this paper was motivated by the lack of a suitable instrument to assess the quality of an ontology in a major Australian Government system. This paper first considers the principles behind ontology and quality then reports on the research project to build and demonstrate an instrument and method to assess the quality of an ontology.

## 1.1 Ontology

Ontology is a term that originated in philosophy meaning the study of existence, of all the kinds of entities – abstract and concrete – that make up the world (Sowa 2000). The study of the categories may include things that exist or may exist in some domain. The product of such a study, called an ontology, is a catalogue of the types of things that are assumed to exist in a domain of interest *D* from the perspective of a person who uses language *L* for the purposes of talking about *D*. The types of ontology represent the predicates, word senses, or concept and relation type of the language *L* when used to discuss topics in domain *D*. The two sources of ontological categories are observation and reasoning. Observation provides knowledge of the physical world, and reasoning makes sense of observation by generating a framework of abstractions (Sowa 2000 p51).

So in the information sciences an ontology specifies the conceptual structure of a real-world domain through its vocabulary and its meaning, or semantics. The conceptual structure comprises definitions of concepts and the rules for the relationships between those concepts. Examples of traditional ontologies include database schemas, taxonomies and library classification schemes. Modern ontologies are designed for the computer and, as well as specifying a common understanding of a domain for its different human users, underlie automated information processes such as interpretation, aggregation, manipulation, etc. As an ontology is fundamental to systems in an organisation its quality is critically important for the sound operation of those systems. We interpret Weber (1997) to be arguing that the Information Systems discipline is, at heart, applied ontology.

Ontologies are designed as a set of concepts and their relations to each other, rules and languages that enable the diverse data and information sets of different computer systems to be handled as if they were inhabitants of the same system (Lambe 2007).

## 1.2 Quality

There are some paradoxical aspects to the concept of *quality*. One account of *quality* considers it to be the subjective experience a person has as a result of their perception of some object or activity. This experience might be described in statements like "this is a good quality wine" or "I rate this wine as a 5 on a 7 point scale". Such statements are descriptive of the state of the respondent not of the wine's quality as such. Comments about the same wine from different people may well be different. Comments from one person may vary considerably depending on the context in which the experience occurred. Probing someone further as to why they think a wine has a certain level of quality yields either more experiential description, an appeal to a particular attribute, with the implied assumption that it is a quality-defining attribute or a frustrated "look, we all know quality when we see it, don't we?". The subjective account of quality is predominant in circumstances where objects or activities are personal services, that is, where there is only one 'user' judging quality, for example the subjective experience of a work of art may lead to a purchase.

But professional Information Systems work is not wholly like the work of an artist. Doubtless, everyone involved in a system will have subjective responses to it, but these can not constitute an objective evaluation of the quality of a system.

It was noted above that when asked why one thinks a wine is good a common response is to point to some aspect of the wine as though describing that aspect accounts for quality. A wine has many properties can be described. The alcohol content might be 12%, *slightly cloudy* the measure of wine clarity, *leathery* a metaphorical description of detectable traces of the chemical brettanomyces and so on. Notice that alcohol content can be measured with technology, clarity by sight (using some pre-determined set of categories) and an educated palette is required to detect brettanomyces. Expert wine tasters can describe emergent properties of a wine; that is those where a number of properties interact in complex ways to produce a discernable character. For example a number of properties, particularly to do with acidity, contribute to a wine's being described as *flabby*. Wine language is regularly ridiculed, but amongst wine professionals it is objective and technical. A wine judgement is open to scrutiny and falsification (Todd, 2010).

But still, none of these descriptions form an assessment of quality. For a set of descriptions to become a quality assessment two a priori decisions need to be taken. First, which particular attributes will count as quality attributes and, second, how the measures of those attribute will be evaluated to yield a quality judgement. For example, the wine-tasting community decides what values of which attributes it will use to classify a wine into gold, silver, bronze or no classification for its class. Quality, as an objective matter, has an agreed meaning for a professional community by which the values of natural attributes can be assessed to yield a measure of quality.

The above two accounts of *quality* distinguish between a subjective, experiential, individual sense of the word and its objective, technical, community sense. *Quality* is a powerful, value-laden word; it is not always easy to separate the two accounts in practice.

Community consensus is fine for wine quality judgment and it is important for what is a huge industry. But in the end, wine is to be subjectively enjoyed. Not so information systems. The quality of a system has powerful organisational and social consequences, quality failures may be life threatening. A firm basis is needed for quality assessment in information systems. If we accept that quality is not inherent in an activity or artefact but is a concept to be derived from attributes that are inherent, then we need to consider and specify what it is that will count as quality in any particular artefact or activity.

One approach to deciding on quality criteria was discussed in McDonald (2006). That work presented a model of systems development that identified the major ingredients and structures involved in systems development. He distinguished three points of quality assurance based on three phenomena in the model - process quality, product quality and impact quality. The properties of these phenomena are different, so the quality attributes derived from them are different, but both subjective and objective means can be used to assess those quality attributes.

***Process Quality*** concerns how well a development process was conducted. Conformance with relevant standards and good development practice is one classic means to assess this quality.The IEEE 1074-1995 standard describes the general software development process, the activities to be carried out and the techniques that can be used for developing software. A method was developed to transfer standards for software engineering to the task of ontology engineering (Luczak-Rosch & Heese 2008) called Methontology. It includes a life cycle that identifies the stage through which the ontology passes during its lifetime (Corcho et. al. 2003). The development process identifies which tasks should be performed when building ontologies (scheduling, control, quality assurance, specification, knowledge acquisition, conceptualization, integration, formalization, implementation, evaluation, maintenance, documentation and configuration (Gomez-Perez 2001 p392). These tasks are phenomena which may be assessed for their quality.

***Product Quality*** verifies the quality attributes of a product in isolation from its development or use. A product being tested against its functional specification is an example of assessing product quality. Conformance with external product standards may be relevant for some products. As the demand for exploiting the reuse of ontologies grows, there is a need for criteria or standards to adequately determine the quality of the ontologies being made available to both humans and agents alike on the Semantic Web (Cross & Pal 2008).

Since the features of many ontology languages are subsets of those found in the Open Knowledge Base Connectivity Protocol (OKBC), Cross and Pal (2008) suggest that any ontology analysis tool be based on an OKBC-compatible language. OKBC is a common query and construction interface for frame-based systems that facilitates interoperability (Chaudhri et. al. 1998 p20).Whilst there is no specific ontology standard, the nature of ontology makes the application of standards for software development and OKBC protocol acceptable. Development of a specific ontology standard may provide research opportunity for the future.

***Impact Quality*** is of two types. Firstly, 'fitness for use' which concentrates on the relationship of the product with the actual user, that is, it views the product as instrument in, or as input to, some other process. To determine impact quality an assessor identifies who the product for, what it will be used for, and its context of use. Secondly, 'stakeholder impact' considers the affects that the system has on the people, organisations and society who are not necessarily direct users of the system. In the end, it is this broader impact that is the final determinant of the quality of the system.

By identifying the potential stakeholders at each point of the ontology life cycle, an indication of the set of quality criteria that each different stakeholder could potentially be interested in can be developed. Identifying the potential quality criteria also provides an opportunity for developers to provide this quality during design and implementation. The various types of stakeholders of ontology appearing the literature are:

Knowledge Engineers; Project Managers;
Ontology Developers (Gangemi et. al. 2006);
Software auditors (human), and virtual software auditors (Burton-Jones et.al. 2005);
System engineers (Cross & Pal 2008); and
End users (Fernandez-Lopez & Gomez-Perez 2002).

This paper agrees that different categories of stakeholders will have different intended uses for the ontology (Fernandez et. al. 1997 p34) at different stages of the ontology life cycle. Each stakeholder deserves explicit individual consideration for responsible (Bittner & Hornecker 2002) and quality (McDonald 2006, 2008) design work.

Quality Assured work is 'evidence-based'. That is, there is evidence that quality of the work has been explicitly defined and measured. Process, product and impact phenomena have quality attributes and, in a quality assured project, measurements of these attributes are recorded, the processes auditable and the product itself testable. It is said that 'if you can't measure it, you can't manage it' but, of course not all quality attributes are quantitative. Some of the most important qualities have to do with perceptions and values. Take the quality 'fits well with the strategic direction of the organisation for example - while this quality attribute cannot be measured, it can be argued for (or against).

While there are general quality standards, *quality* always relates to some specific phenomena. General ideas about what to measure (correctness, modifiability, testability, usability, reliability, efficiency, integrity, reusability, interoperability, etc.) can be useful guides but each unique product, process and impact needs its own quality criteria to be established and satisfied.

# 2 THE RESEARCH PROBLEM AND APPROACH

When it comes to conducting an assessment of the quality of an ontology there is a problem in that there seems to be no systematic instrument or method for doing it. There is an abundance of literature proposing ideas about what constitutes a 'good' ontology, but it seems diverse and largely untested. That is, with the exception of the developing body of work in computer science that is generating automated quality assurance algorithms, especially in bioinformatics (for example,Verspoor et. al. 2010).

The aim of the research reported here is to review the literature and produce and demonstrate a well-grounded instrument for assessing the quality of an ontology. The research method comprised 5 steps.

1. The first involved an extensive review of the literature to identify QA approaches and criteria.
2. In the second step, the attributes were critiqued and put into a common format and refined, eliminating duplicates, to produce an alphabetic list of criteria.
3. Step 3 deployed theories of quality to classify the criteria into a usable structure.

4. Step 4 produced a practical instrument for quality assessment.
5. The instrument was demonstrated in the final step of the research.

The production of the instrument places this research into the design-science paradigm, that is, it contributes a new and innovative artefact for practitioner use in addition to scholarly contribution.

## 2.1 Quality Attributes from the Literature

There exists literature, not specific to ontology, which contributes ideas about candidate quality attributes. As an ontology is a type of information artifact, the information quality literature is relevant. Knight & Burn (2005) for example review a number of quality frameworks in their work on quality assessment of web information. The data quality literature is another rich source of attributes. For instance, Ballou and Pazer (1985) produced a set of attributes; Wang and Strong (1996) proposed an ontology for data quality dimensions and this was followed by Tayi (1999) and Cappiello (2005). Thomas Gruber, who coined the common definition of ontology as it is used in the information systems (the specification of a conceptualization) provided five features of an 'adequate ontology: clarity, coherence, extendibility, minimal encoding bias and minimal ontological commitment' (1993).

A literature search was conducted to find sources which presented quality attributes. The search detected 181 publications that contained quality criteria.

The assembly of these criteria into an alphabetic list, removing duplicates and instances of nearly identical criteria resulted in the identification of 215 discrete criteria.

Table 1 shows a fragment of the list of criteria.

| **Quality Attribute** | **Description** | **Author(s) - reference** |
|---|---|---|
| ... | | |
| 24. Compartmentalization | The extent to which the design provides an understanding of the possible ways one could divide the ontology. | (Pinto & Martins, 2001) |
| 25. Completeness | The extent to which ontology elements are not missing and are of sufficient depth or breadth for the task at hand. | (Burton-Jones, Storey, Sugumaran, & Ahluwalia, 2004), (Weber R. , 1997), (Wang & Strong, 1996), (Cappiello, 2005), (Redman, 1996), (Jarke, Lenzerini, Vassiliou, & Vassiliadis, 2000), (Gomez-Perez A. , 1995), (Gennari, Tu, Rothenfluh, & Musen, 1994) (Gomez-Perez, Juristo, & Pazos, 1995), (Fernandez-Lopez & Gomez-Perez, 2002), (Pipino, Lee, & Wang, 2002) |
| 26. Components | The extent to which the entities / attributes / processes / entities re-use ontology components. | (Uschold M. , 1996) |
| 28. Comprehensiveness | The extent to which ontologists, domain experts and others agree about the comprehensiveness of the domain. | (Burton-Jones, Storey, Sugumaran, & Ahluwalia, 2004), (Jarke, Jeusfeld, Quix, & Vassiliadis, 1999), (Redman, 1996), (Cappiello, 2005), (Soares, da Silva, & Simoes, 2010) |
| ... 176. Wholeness | ... | ... |

*Table 1.A sample of the 175 quality attributes and their sources.*

This alphabetic list was too cumbersome to use as a quality assessment instrument, so it was organised into a more usable form using framework approaches found in the literature search.

## 2.2 Analyzing the Quality Attributes

An information quality framework typically consists of a set of quality criteria and their definitions grouped into general categories that have been separately defined. Wang and Wand (1996) used a restricted framework that has been criticized for being intuitive rather than theoretical (Shanks & Price 2005 p89). The McDonald (2006) approach to assessing artifact quality was to group criteria relevant to the phenomenon of assessment (the development process, the product or the impact). While useful it was a general framework for any form of artifact.

In 2000 Naumann and Rolker developed a set of information quality criteria categorized on how each criterion is assessed. They used three points of view:

assessment with respect to the user of information (**subject**-criteria);
assessment with respect to the information source itself (**object**-criteria); and
assessment with respect to the query process (**process**-criteria).

The Naumann and Rolker approach is rather numeric, requiring each criterion to be assessed using scores. However in our attempts to define meaningful and useful measurements for each assessment class insuperable problems and uncertainties arose. At this point the research moved away from quantification and towards an approach of using the criteria to identify attributes that should be examined and evaluating what was discovered in a risk analysis style.

The 220 criteria from the literature were classified into the upper 3 categories then into broad and narrow criteria:

| | |
|---|---|
| Upper | 3 categories depending on how the criteria is assessed: subject, object or process |
| Broad | 31 Ontology Quality criteria |
| Narrow | 189 Ontology Quality sub-criteria |

This schema was then used to create an assessment instrument.

## 2.3 Deriving a Quality Assessment Instrument

Several requirements and goals were formulated prior to, and considered throughout, the derivation process to ensure a systematic and rigorous evaluation of potential quality criteria. The requirements are as follows:

quality criteria must be general, i.e. applicable across application domains and data types,
quality criteria must clearly defined,
quality criteria must be expressed as adjectives to ensure consistency, and
overlap (i.e. interdependencies) between criteria must be fully documented and justified.

The goals are as follows:

the names of quality criteria should be intuitive,
i.e. corresponding as closely as possible to common usage,
quality criteria should be non-overlapping (i.e. not have dependencies on other criteria), and
the set of quality criteria should be comprehensive.

These goals are listed separately from requirements since there may be circumstances where the first two goals may not be completely satisfiable and we cannot prove that the last goal is satisfied—it can only be subjectively assessed over time through peer review and empirical feedback (Price & Shanks 2004).

The Price and Shanks approach to defining criteria using adjectives was used to derive a standard approach to the common language of the criterion definition.

For each narrow criterion at least one example is provided to guide the assessor to quality attributes that may be reviewed. The type of response was very dependent on the type of criteria, sometimes numeric, often not. Table 2 shows part of the instrument concerning the broad criteria 'Completeness', the general questions an assessor might ask about it and its specific criteria (in square brackets).

| **Ontology Quality Assessment Instrument**<br><br>**Object Criteria** | |
|---|---|
| **Completeness** | **The extent to which ontology (including its data / information) elements are not missing and are of sufficient depth or breadth for the task at hand.** |

**Some examples for assessing *Completeness* include understanding :**

***14.0*** *whether the ontology (whole or part of real-world) has been clearly articulated and sufficiently developed to facilitate all known tasks* ***[Completeness]***

***14.1*** *how many concepts (business rules, relationships) are covered by the ontology* ***[concepts]***

***14.2*** *what percentage of the domain concepts (business rules, relationships) is covered by the ontology* ***[coverage]***

***14.3*** *whether each system or sub-system defines each event as either external or internal* ***[events]***

***14.4*** *whether an estimate of the amount of infrastructure knowledge being represented by the ontology divided by total infrastructure knowledge of the organization can be calculated* ***[infrastructure]***

***14.5*** *whether the ontology inheritance richness can be calculated i.e. the distribution of information in the current class subtree per class* ***[inheritance]***

***14.6*** *how large the ontology is, and whether it is bigger than others modeling the same domain* ***[largeness]***

**...**

*Table 2.A sample of the quality assessment instrument for the 'completeness' criterion*

A limitation of the research is that has not yet tested the validity of the quality attribute categorisation. A future project is needed here, perhaps using a Delphi study or Card Sorting approach.

## 2.4 Using the Instrument

To deploy the instrument a disciplined process for conducting the quality assessment needed to be developed as no suitable one was found. The following 7 steps were determined as being necessary to understand the criterion, its application and the results of the assessment.

| | | |
|---|---|---|
| Step 1 | Risk statement | *A statement of any risk of not satisfying this criterion - "what can happen and why?* (Introduction IEC/ISO 31010*)"* (International Electrotechnical Commission, 2009-11) |
| Step 2 | Result Type | *An explanation of the result of the judgment, i.e. a percentage, yes/no, true/false, a number, a dollar, etc. and any constraints to the result based on the wording of the definition- "what are the consequences?"* (Introduction - IEC/ISO 31010) (International Electrotechnical Commission, 2009-11) |

| | | |
|---|---|---|
| Step 3 | Result formula | *A blank formula providing a possible explanation of the result of the applied criterion - "establish the context for identifying, analyzing, evaluating, treating risk associated with any activity, process,, function or product"* (Introduction IEC/ISO 31010) (International Electrotechnical Commission, 2009-11) |
| Step 4 | The review | *Explanation of the review process for this criterion - how was the risk "analyzed and/or evaluated"* (Introduction IEC/ISO 31010). (International Electrotechnical Commission, 2009-11) |
| Step 5 | Deficiencies | *Any deficiencies in locating the sources or clarifying the meaning of any definitions are highlighted, and a possible result of the deficiency is to be briefly discussed-* highlight any difficult in interpreting, locating or *"tracing"* (Section 5.7 AS/NZS ISO 31000:2009) (Standards Australia) |
| Step 6 | The result | *A description of the result* |
| Step 7 | The Conclusion | *A comment about what the result means in practice* - "the significance of a risk" (section 22 AS/NZS ISO 31000:2009) (Standards Australia) |

The instrument, and these 7 steps, was then applied to a case study.

# 3 FINDINGS

The case study concerned the assessment of the Australian Government's Standard Business Reporting ontology by the Queensland University of Technology which may, in the future, need to know whether it could effectively use Standard Business Reporting.

## 3.1 Demonstration Case: Standard Business Reporting Ontology

Standard Business Reporting (SBR) is an initiative of the Council of Australian Governments (COAG). Through various commercial accounting software systems small to medium businesses and their intermediaries are able to access data stored in their business systems, review the data for acceptance and lodgment into SBR forms for remittance to different government agencies to satisfy a myriad of reporting purposes. SBR has developed an ontology that is used by the commercial software to report information using a common vocabulary. By using the SBR common vocabulary business reporting becomes less burdensome as those completing the forms have access to definitions and guidance to the meaning of terms, and these terms have been harmonized by receiving agencies to provide concise representation across agencies and forms. This allows information held in business systems to be directed to different agencies without additional reformatting depending on any particular processing requirements of the receiving agency.

The Queensland University of Technology (QUT) is also developing an ontology in the form of a standard chart of accounts to report receipt and spending of Government grants funding by not-for-profit (NFP) firms. Their stakeholders are required to deal with a number of different government agencies, and they too have harmonized a vocabulary for the purposes of minimizing the manipulation for data being submitted to these individual agencies.

The QUT goal is aligned with the goal of the SBR and therefore represents an ideal candidate for SBR extension. How would the QUT ontology developers assess the quality of the SBR ontology? How would SBR ontology developers assess the quality of the NFP ontology? Both taxonomies have been developed independently. What methods are provided in literature for decision makers who are considering re-use of ontology such as SBR for reducing the effort and cost in developing ontology from scratch, when there exists a likely fit that may be suitable. The case study assessment is undertaken from the point of view of the QUT, which is interested in evaluating the quality of the SBR ontology for their use.

The 7 process steps were applied to the first three sub-criteria to demonstrate the instrument, and to gain an understanding of how the QUT would assess the ‘completeness’ quality criteria using the developed quality ontology. Table 3 shows the results of the assessment instrument on the 'completeness' criteria.

<table>
<tr><th colspan="2">QUT - SBR Ontology Quality Assessment</th></tr>
<tr><td colspan="2">Criterion14: Completeness - The extent to which ontology (including its data / information) elements are not missing and are of sufficient depth or breadth for the task at hand<br><br>The core question: Has the whole or part of real-world domain been clearly articulated and sufficiently developed in the ontology to facilitate all known tasks?</td></tr>
<tr><td>Step 1<br>Risk statement</td><td>Completeness is a critical criterion. If the ontology is incomplete required functionality will not be available, or will be of limited value.</td></tr>
<tr><td>Step 2<br>Result type</td><td>Number: because the elements required for the QUT NFP ontology exist and can be counted. A check of the SBR Definitional ontology will require a match of element by element, and a result will emerge. Gaps in elements defined will require work, so will definitions that are not quite matching with existing element definitions.</td></tr>
<tr><td>Step 3<br>Result formula</td><td>Of the 'x' data elements required by QUT NFP, 'a' number are present in the SBR Definitional ontology, 'b' number require harmonization with existing terms, and 'c' will require some processing (definition and harmonization) to introduce them.</td></tr>
<tr><td>Step 4<br>The review</td><td>The QUT has published a Standard Chart of Accounts (and Data Dictionary) July 2006 version. This was used to compare the existing ontology elements in the SBR. The ontology viewing tool Yeti was scanned using keywords from the term from the QUT Chart of Accounts. Potential terms were highlighted. Given that it can be assumed that QUT would ideally prefer a unique code for each element in their chart of accounts, the elements that could be covered by a general higher level code were highlighted. For example SBR provides a code Expense Operating Cost Of Sales Amount. It does not provide a specific code for the Cost Of Sales Expenses such as Accounting Fees, Advertising Expenses, Agency Temporary Staff, etc. Whilst they were counted as matching ‘in principle’ further work would be required to harmonize, or tailor the code correctly for one-to-one use by QUT.</td></tr>
<tr><td>Step 5<br>Deficiencies</td><td>General observation<br>In the SBR ontology there does not seem to be a requirement for recurrent, non-recurrent, capital splits but quite a different set:<br>- Government Funding Adjustment For Government Grants Amount<br>- Government Funding Government Industry Payments Assessable Amount<br>- Government Funding Government Industry Payments Includes Fuel Indicator<br>- Government Funding Operations Costs Amount<br>- Government Funding Receipts From Government Grants Classified as Financing Activities Amount<br>- Government Funding Receipts From Government Grants Classified As Investing Activities Amount<br>- Government Funding Receipts From Government Grants Classified As Operating Activities Amount</td></tr>
</table>

| | |
|---|---|
| | - Research And Development Entitlement To Government Grants And Recoupments Attributable To Foreign Owned Expenditure Amount<br>- Research And Development Grants And Recoupments Attributable To Foreign Owned Expenditure Amount<br>- Research And Development Grants And Recoupments On Australian Owned R&D Incremental Expenditure Amount.<br>***Specific observations***<br>The following concepts were not matched in the SBR ontology.<br>The majority are 'specific' to grants processing, which is understandable as no work to include not for profits grants processing has been commenced, but the two elements hire purchase and lease liability were surprising gaps.<br>2-1210 Hire Purchase Liability<br>2-1220 Lease Liability<br>2-1230 Revenue Received in Advance<br>...<br>4-1090 Grants (Local) - *Capital*<br>4-1100 Grants - *Other*<br>4-2000 Fundraising - Gifts<br>4-2020 Tax Deductible Donations (Non-public)<br>4-2030 Donations (Public Collections)<br>4-2040 Non-tax deductible gifts<br>4-2050 Bequests |
| Step 6<br>The result | Of the 213 data element required by QUT NFP, 193 or (91%) appear to have likely matches present in the SBR Definitional ontology. Refinement appears to be required for 127 of the 193 or approximately 66% of these matches. |
| Step 7<br>The conclusion | It could be concluded that as 85% of the terms in the QUT chart of accounts is covered, including the specific terms that would be essential to collect and process government reporting of grants funding the use of SBR is possible and. pproviding the risks are tolerable, there would be no need for QUT to separately maintain its own taxonomy. |

*Table 3. A sample of the use of the instrument in the SBR - QUT case study.*

The results show the level of detail that is exposed by the use of the instrument. In this case the changes to SBR that would be required have been identified and qualified. A better understanding of the ontology has been generated and the decision as how to proceed with the system is much better informed as a result of the assessment.

But two significant issues in using the instrument became apparent. First was the difficulty of grounding some of the criteria in the actuality of the case. Abstract criteria, like 'expressiveness', are very difficult to operationalize and need a good deal of ontological work to tease out their nature sufficiently to allow them to be assessed in a particular product. Step 1 in the assessment process, requiring the assessor to specify risk if a quality attribute is found deficient was very useful in operationalising quality attributes.

A second issue arises in the interpreting of the results of some assessments. To have an 85% coverage may in some cases be only a small issue, but in other cases huge. Again, step 1 of the process was useful in establishing the reason why a quality deficiency would be important and hence a means of interpreting the measure of it.

Identifying quality issues is important in a re-use scenario. Once quality issues have been identified an assessor may then conduct a risk analysis in order to manage the risks, or to determine that reuse of the ontology is simply not an option. The Ontology Quality Assessment Instrument has been designed as a tool for practitioners that has operationalized the literature for practical use.

# 4 CONCLUSIONS

In the absence of the ontology quality assessment instrument that has been proposed in this research, it is unclear how the myriad of references in the literature that apply, or can be assumed to apply to the domain of *'Ontology Quality'* could be operationalized. Whilst quality assessors are able to rely on the broader standards for systems quality evaluation, there is much work done by the ontology community in understanding the process of ontology quality assessment.

This research captures the criteria, as it exists in literature, and works it into an instrument specifically to conduct an assessment of the quality of an ontology. The case study demonstrates the application of the instrument and reveals the kinds of issues that can be detected and quantified - particularly those relating to the overly abstract nature of many criteria and the difficulties in interpretation of data collected against some criteria.

Avoiding the significant costs of developing and deploying ontology is possible by adopting an existing ontology. As an artifact or object, the assessment of an ontology is an assessment of its overall value, or its quality. The case study demonstrated the application of the instrument and revealed some gaps that currently confuse the assessors of ontology to the extent that, they are more willing to develop an ontology from scratch rather than attempting the challenging task of assessing its quality.

Further refinement of the instrument and the evaluation method is expected to occur as the instrument is used in practice by ontology developers and assessors.

There is significant challenging work ahead to better define ontological quality and to mobilize that knowledge in practice. It is hoped that this work provides a contribution to the theory and practice of assessing '*The Quality of an Ontology*'.

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