Ontology Evaluation through Usability Measures

An Experiment with the SUS Scale in the Legal Domain

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Abstract. Current ontology methodologies offer guidance towards knowledge acquisition, ontology development (design and conceptualization), formalization, evaluation, evolution and maintenance. Nevertheless, these methodologies describe most of expert involvements within ontology validation rather vaguely. The use of tailored *usability* methods for ontology evaluation could offer the establishment of certain quality measurements and aid the evaluation of modelling decisions, prior ontology implementation. This paper describes the experimental evaluation of a legal ontology, the Ontology of Professional Judicial Knowledge (OPJK), with the SUS questionnaire, a usability evaluation questionnaire tailored to ontology evaluation.

1 Introduction

Although there are many approaches to ontology evaluation, very few are directed towards the evaluation of the quality of the conceptual content of the ontology. These evaluations could offer relevant insights, especially, for the development of ontologies based on expert knowledge, or in our research, for ontologies based on legal professional knowledge.

"Evaluation of ontologies refers to the correct building of the content of the ontology, that is, ensuring that its definitions (a definition is written in natural language and in a formal language) correctly implement ontology requirements and competency questions or perform correctly in the real world" [1]. Most ontology engineering methodologies include, generally, an evaluation stage, although different proposals regarding its actual performance are offered. In this sense, an evaluation is a recursive process, a cyclic activity; findings during evaluation may require ontology refinement, further knowledge acquisition, and as a consequence, also further conceptualization and validation [2].

Regarding evaluation within ontology methodologies, [3] proposed an ontology evaluation based on the competency questions set for the development of the ontology. [1] proposes a life-cycle evaluation, based on the implementation of the requirements, and the validation of definitions, consistency, completeness and conciseness. User assessment is envisaged as an evaluation activity towards ontology reuse. [2] suggested a technology-focused evaluation (formal language—syntax—and consistency), a user-focused evaluation (requirements specification document, including competency questions), and an ontology-focused evaluation (including verification and validation).

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Finally, UPON [Unified Process for Ontology Building] and OntoLearn include the participation of domain experts in the validation phase, and in the validation cycle towards ontology learning and extraction (see [4,5], respectively).

Moreover, evaluation (validation, verification and assessment) and quality measurement of ontologies are currently an important topic of research, especially towards ontology implementation and ontology assessment or comparison for reuse purposes.[1] The organization of the EON and OntoContent workshops series,[2] together with new evaluation and measurement proposals, demonstrate the relevance of this activity both for ontology development and comparison for reuse. Evaluation according to philosophical notions such as *identity* or *unity* (the OntoClean methodology by [11]), according to schema and instance metrics (OntoQA evaluation by [12]), and the work of [13,14] regarding the design of ontology metrics, are some examples of these proposals.

As mentioned above, few of these evaluation techniques or methodologies may evaluate the quality of the conceptual content of ontologies, and although some ontology methodologies involve experts during the validation process, most of these expert involvements are described rather vaguely. In order to explore some solutions to support expert evaluation in expert knowledge ontology engineering, we conducted an experiment to study if the use of adapted usability measures (usability questionnaires) could offer relevant ontology evaluation results. This experiment was carried out during the development process of a legal ontology engineered from professional knowledge of judges in practice: the Ontology of Professional Judicial Knowledge [15,16,17].

Human-centred software design and user validation are highly standardized processes which include participation in and evaluation of the general development of software, systems and products, the analysis of their usability, the documentation provided and the quality of their use. Moreover, usability engineering may take into account the effectiveness, efficiency and satisfaction offered by the use of a product (in a certain context), the user interface development process, and the validation of the activities performed during the development process of a product.[3]

Therefore, ontology engineering could benefit from the inclusion of several systematic human-centred methods in the ontology development life-cycle, specially towards the construction of domain and core ontologies for specific areas of knowledge, especially those which include the modelling of expert knowledge. Knowledge acquisition for ontology modelling, evaluation of ontologies and the production of documentation would directly benefit from the application of a similar approach. Moreover, the use of these measures could offer grounds for further ontology comparison, for research into

[1] Some authors refer to this step as *ontology evaluation*, although the main purpose of this assessment is ontology reuse and comparison, rather than the conceptual and quality improvement of a particular ontology [6,7,8]. OntoMetric, for example, is a tool that "allows the users to measure the suitability of the existent ontologies, regarding the requirements of their systems" [9]. See also [10] and the European project SEALS (`http://www.seals-project.eu`).

[2] Visit the 5th International EON [Evaluation of Ontologies and Ontology-based tools] Workshop at `http://km.aifb.uni-karlsruhe.de/ws/eon2007`, retrieved November 10, 2008, and the 3rd OntoContent workshop at `http://mature-ip.eu/en/ontocontent2008`, retrieved November 10, 2008.

[3] For example, human and user-centred design for life cycle of interactive computer-based systems [18], usability methods [19], and the evaluation of quality in use [20,21].

ontology sharedness measurements, and foster expert participation in the development of ontologies based on professional or expert knowledge.

This paper describes this experimental evaluation, based on the adaptation of the System Usability Scale developed by [22] to ontology (sharedness) validation. Section 2, briefly describes the Ontology of Professional Judicial Knowledge (OPJK) of the IURISERVICE application. Section 3 outlines the results obtained from an *ad hoc* evaluative activity of the Ontology of Professional Judicial Knowledge, and section 4 offers the description of the evaluative experiment with the SUS questionnnaire and the comparison of results. Finally, some conclusions and further work are outlined.

2 Ontology of Professional Judicial Knowledge

The purpose of the Ontology of Professional Judicial Knowledge was to semantically enhance the search and retrieval capabilities of IURISERVICE, a web-based application that supports legal decision making during the on-call period of Spanish newly recruited judges. The need for the IURISERVICE system and its initial design was established as a result of a thorough ethnographic survey carried out with the collaboration of the Spanish General Council of the Judiciary (CGPJ). From the findings of this survey, the research team assumed that:

- Judges in their first appointment solve several practical problems during their first months of work, mostly during the on-duty period.
- This knowledge was acquired mainly by practice.
- A repository of possible solutions based on experience towards practical problems could offer valuable support for the newly appointed judges. Such a system could also be useful to the judicial profession itself in order to distribute, maintain, and avoid inconsistencies of this practical knowledge.
- As use of the Internet/Intranet was widespread among judges, a web-based FAQ system with a simple natural language interface could be designed.
- If a system was to provide efficient support in a reliable manner, the repository of knowledge and its accuracy and validity (answers to questions regarding practical problems of the judicial profession) were critical.
- During the on-call period, time and accuracy (semantics rather than on simple keyword matching) were also critical issues.

Due to these findings, the IURISERVICE application was designed to provide on-line access to an FAQ (Frequently Asked Questions) system that allowed users (judges) to search for practical (experience) questions in a repository. The overall design of the system is based on the need for effectiveness: the system should be able to locate the best possible matching FAQ question to the user's input question that tackles the problem. The use of semantic technologies, through the use of ontologies, in the system was aimed at providing more accurate searches than the basic keyword search.

Therefore, the OPJK ontology needed to represent the relevant concepts related to the problems that took place during the on-call period: domain specific knowledge. This professional knowledge gathered by experience from the practice during on-call period was acquired in interviews aimed at eliciting the problems (questions) that judges

faced in their first appointment. From these interviews, a corpus of nearly 800 practical questions was obtained; this corpus constituted the main knowledge source towards OPJK ontology conceptualization.

Two versions of OPJK were produced in order to facilitate computation capabilities and to obtain significant technical evaluation results in the future. The main classes and their subclasses of the Ontology of Professional Judicial Knowledge were: `Role` (e.g. `Judicial_Role, Procedural_Role, Family_Role`), `Act` (e.g. `Procedural_Act`, `Agent` (e.g. `Judicial_Organization, Penal_Institution`), `Document` (e.g. `Legislative_ Document, Judicial_Document`), and `Process` (e.g. `Appeal_Procedure, Hearing`). The development process, including knowledge acquisition, conceptualization, and formalization has been described by [23,24].

3 OPJK Evaluation

The evaluation of the Ontology of Professional Judicial Knowledge included, then, a purpose-focused evaluation and an ontology-focused evaluation. The evaluation of the purpose was based on the analysis of the specification of requirements and competency questions established in the Ontology Requirements Specification Document against the final OPJK ontology. Nevertheless, in this paper, we focus on the description of the ontology-focused evaluation, which comprehended the verification of the correctness of an ontology, and the validation of the representation offered. [2] refers to them as the evaluation of "building the system right" and "building the right system", respectively.

As the Ontology of Professional Judicial Knowledge models conceptual expert professional legal knowledge, ontology-focused validation activities required the involvement of legal professionals or *legal experts* to validate the knowledge that the OPJK ontology represents, thus, to validate the shareability of the conceptualization formalized under the established requirements.

3.1 Language Conformity and Consistency Checking

The domain knowledge contained in the ontology was first represented in a lightweight manner, and complexity was added with the use of OWL as representation language in the following versions of the Ontology of Professional Judicial Knowledge. The use of the Protégé knowledge acquisition tool and ontology editor allows consistency checking through the Pellet reasoner, and prevents the incorrect usage of the OWL language in the construction of ontologies [2]. All OPJK versions were found consistent by the Pellet reasoner used by the Protégé editor.

3.2 Legal Expert's Validation

In order to evaluate the content of the ontology, debriefing sessions were set for different groups of legal experts (professionals and academics) in order to inform them of the purpose of the Ontology of Professional Judicial Knowledge, its requirements, its conceptual particularities, and the process of conceptualization followed, based on the corpus of questions provided by the judges in their first appointment during the

surveys carried out during 2004. At the end of these debriefing sessions, the experts were required to answer an *ad hoc* questionnaire, designed to evaluate specifically different features of the OPJK ontology and, to provide suggestions for improvement (following Nielsen's approach [25]).

A group of 9 legal experts (academics, professionals and researchers) working at or collaborating with the Faculty of Law of the Universitat Autònoma de Barcelona took part in the evaluation. From these legal experts, 7 had 6 or more years of working experience (3 experts had 10 years or more). Regarding the area of expertise, there were experts in substantive law—public and private law—(3), procedural law (2), and in the areas of legal theory, legal sociology or legal history (4). Finally, from the total of participants, 3 were legal professionals (2 lawyers and 1 judge), 3 were legal researchers (Law & Technology), and 3 were legal academics.

This questionnaire contained a total of 48 questions regarding several aspects of the OPJK conceptualization: concepts, definitions, instances, and relations. The evaluation of the complete ontology (56 classes, 913 instances, 24 `owl:ObjectProperty` axioms (10 `rdfs:subPropertyOf` and 12 `owl:inverseOf`), 2 `owl:equivalentClass` axioms, 77 `owl:disjointWith` axioms, 80 multiple class instantiation constructs, 51 `owl:sameAs` axioms) was considered a lenghtly and time consuming activity with respect to the limited access to experts' time. Therefore, the evaluation was designed to include the validation of the complete taxonomical structure (56 classes), and the revision of 14 concept defintions, 49 instance classifications, 9 property relations, 4 multiple class instantiations, and 4 equivalent instance relations.[4]

The experts were asked to express their opinion regarding their level of agreement with the conceptualization, understood as acceptance of the specific conceptualization decision with regards to the purpose of the ontology), according to a Likert scale, a 1 to 5 scale, where 1 corresponds to "highly disagree" and 5 to highly agree. Finally, the evaluation of the features was carried out on these different levels of the ontology separately, as suggested by [8].

First, legal experts performed an evaluation of each of OPJK main classes and some of the natural language definitions provided for them: `Agent`, `Document`, `Act`, `Process`, and `Role`. The experts highly agreed or agreed in 27.78% and in 36.11%, respectively, to the taxonomical conceptualization of classes (A, see table 1 below), which represented a 63.89% of general agreement. Nevertheless some high disagreement (5.56%) was also expressed.[5]

Then, the experts were asked to evaluate the natural language definitions provided for some of the most characteristic concepts of the OPJK ontology with relation to the judicial setting (judicial organization, procedural role, legal document, legal act, criminal act, procedural act, etc.) `Judicial_Decision_Organization`, `Procedural_Role`, `Legal_Document`, `Legal_Act`, `Criminal_Act` and `Procedural_Act`. Also, the definitions provided for `Macroprocess`, `Microprocess` and `Family_Role` were included

[4] The specific contents of the questions were chosen by their modelling complexity, based on a previous validation experience and design discussions during the conceptualization process, and conceptualization difficulties.

[5] There was no wide disagreement between the experts regarding a specific class, although the `Agent` class obtained a "high agree" from 8 out of 9 experts.

to validate their acceptance. The overall agreement of the experts with the questions included in this first section (class conceptualization—A— and class definitions—B and C—) was of 62.96%, including "high agree" and "agree"(while high disagreement represented a 4.32%). Judicial_Organization, Family_Role, Microprocess, and Legal_Act, were the definitions most disagreed upon.

The next section of the evaluation questionnaire included 13 questions related to the classification of instances (D). For example, the experts were asked about their agreement regarding the classification of donation and purchase as instances of Legal_Act, or plaintiff, defendant, complainant as instances of Criminal_Procedural_Role. The overall level of agreement on the classification of instances, taking into account results from both "high agree" and "agree" options, was of the 82.9%. Nevertheless, most experts "disagree" and "highly disagree" with several instantiations (judicial_office as Judicial_Government_Organization, and of town_hall and social_services as Local_Organization).

In the following section of the evaluation questionnaire, the experts were required to evaluate several relations established between the conceptualized classes, and to express their degree of agreement with several owl:Object_Property and rdfs:subPropertyOf constructs and with a set of multiple class instantiation and owl:sameAs constructs (E and F). A total of 75.82% of general agreement (35.95% "highly agree" and 39.87% "agree") was obtained. The last set of questions of the evaluation questionnaire comprehended the validation of multiple class instantiation and owl:sameAs constructs.

In total, the experts were asked to validate 48 items. Their overall levels of agreement with the general conceptualization offered (class, subclass, instantiation, properties, etc.) was of 72.92% (high agreement 32.41% and agreement 40.51%) in total. Table 1 below includes all the specific results.

Finally, during these debriefing sessions the experts made several relevant suggestions, generally related to the taxonomical classifications and concept definitions showing the lowest scores, for the improvement of the OPJK ontology. In general, the taxonomical structure of Process and Act was found rather complex. Also, although the class structure for Organization and Role was considered correct, minor revisions could provide major improvement. Moreover, slight changes in labels and definitions could offer clarity and foster expert understanding and agreement. These suggestions were taken into account towards OPJK refinement (see, for more details, [23].

Table 1. Evaluation results

	Groups of questions						
Levels	**A**	**B**	**C**	**D**	**E**	**F**	**Totals**
High agreement	27.78%	35.56%	17.28%	38.46%	34.57%	37.50%	32.41%
Agreement	36.11%	42.22%	37.04%	44.44%	40.74%	38.89%	40.51%
Indifferent	19.44%	15.56%	14.81%	9.40%	16.05%	9.72%	13.19%
Disagreement	11.11%	6.67%	24.69%	4.27%	7.41%	11.11%	10.65%
High disagreement	5.56%	0.00%	6.17%	3.42%	1.23%	2.78%	3.24%
TOTALS	100%	100%	100%	100%	100%	100%	100%

Both the debriefing sessions and the questionnaires offered very valuable information regarding the conceptualization of the OPJK ontology and its refinement. Nevertheless, neither the questionnaire and the evaluation results were easily exportable towards the evaluation of other ontologies, nor a systematic approach towards the evaluation of ontologies by experts was supported.

4 *Usability* Evaluation Experiment

Therefore, as mentioned in Section 1, also at the end of the debriefing sessions, the experts were asked to answer a tailored version of the System Usability Scale (SUS) questionnaire, in order to evaluate the understanding and agreement felt by the legal experts regarding the Ontology of Professional Judicial Knowledge as a whole.

The System Usability Scale, developed by [22], is a ten-item Likert scale (stating the degree of agreement or disagreement), elaborated initially to evaluate the usability of a system. The SUS score "yields a single number representing a composite measure of the overall usability of the system being studied" [22]. The use of this questionnaire is recommended by the UsabilityNet project website as "it is very robust and has been extensively used and adapted. Of all the public domain questionnaires, this is the most strongly recommended". Also, in a comparsion between different questionnaires to assess website usability (the SUS was tailored to website evaluation) it was found that "one of the simplest questionnaires studied, [SUS], yielded among the most reliable results across sample sizes" [26].

The scale was, in this experiment, translated into Spanish and tailored to evaluate the understanding and acceptance of the contents of the ontology, regarding its purpose. The original sense of the questions was maintained as far as the tailoring allowed.[6] For example, question 3: "I found the system was easy to use" was modifed by "I found the ontology easy to understand" (see Table 2). In this case, this legal expert's validation plays a similar role to *usability inspection* for a software product [27].

Once the SUS score had been calculated, the overall results obtained with the SUS questionnaire were of the 69.44%, which suggested a high level of agreement with the general OPJK conceptualization. Furthermore, a comparison between the results obtained in the specific (*ad hoc*) and comprehensive OPJK questionnaire (72.92%) and the results of the SUS 10-item questionnaire (69.44%) shows a high degree of similarity. This may also suggest that the use of short but well-designed ontology evaluation questionnaire, based on the idea of usability questionnaires for software products, could offer rapid feedback and support towards the establishment of relevant agreement, shareability or quality of content measurements in expert-based ontology evaluation.

[6] The original SUS questions are: 1) I think that I would like to use this system frequently, 2) I found the system unnecessarily complex, 3) I thought the system was easy to use, 4) I think that I would need the support of a technical person to be able to use this system, 5) I found the various functions in this system were well integrated, 6) I thought there was too much inconsistency in this system, 7) I would imagine that most people would learn to use this system very quickly, 8) I found the system very cumbersome to use, 9) I felt very confident using the system, and 10) I needed to learn a lot of things before I could get going with this system.

Table 2. SUS Ontology Evaluation Questionnaire

	1	2	3	4	5
1. I think that I could contribute to this ontology					
2. I found the ontology unnecessarily complex					
3. I find the ontology easy to understand					
4. I think that I would need further theoretical support to be able to understand this ontology					
5. I found the various concepts in this system were well integrated					
6. I thought there was too much inconsistency in this ontology					
7. I would imagine that most legal experts would understand this ontology very quickly					
8. I found the ontology very cumbersome to understand					
9. I am confident I understand the conceptualization of the ontology					
10. I needed to ask a lot of questions before I could understand the conceptualization of the ontology					

5 Conclusions and Further Work

This paper outlines some evaluation activities of the Ontology of Professional Judicial Knowledge. Different purpose and ontological evaluative tasks were carried out, and favourable results were obtained by the analysis of the specification of requirements and competency questions, language conformity, and consistency checking. However, special interest was placed in the performance of a legal expert validation.

This expert validation included both a specific validation of OPJK classes, subclass relationships, properties and instances and a more general and experimental validation based on a usability questionnaire, the System Usability Scale in particular. The results of these validations suggested that there was room for improvement regarding class conceptualization which could offer more granularity and foster understanding and shareability amongst experts. More importantly, the total results from both questionnaires showed a high degree of similarity, 72.92% and 69.44%, respectively, which may suggest that the use of a well-designed evaluation questionnaire (or a *shareability* questionnaire), based on the idea of usability questionnaires for software products, could offer support towards expert-based ontology evaluation and allow rapid (general) content validation.

Currently, few ontology methodologies give precise guidelines or recommendations regarding ontology evaluation, especially, regarding the involvement of experts (or professionals) in ontological expert knowledge evaluation. The use of tailored *usability* methods for ontology evaluation could offer the establishment of certain quality measurements and aid the evaluation of modelling decisions, prior ontology implementation. Thus, as requirement specification, testing and producing end-user documentation are central to enhance the quality and usability of the resulting product, these human-centred steps may enhance the **quality** and **sharedness** of the resulting ontology.

This approach will be further tested and evaluated in ongoing legal ontology engineering projects, which require the participation of experts and legal professionals in the knowledge acquisition, conceptualization and evaluation stages.

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