Domain Ontology Evaluation in Software Development: Questionnaire Proposal

Maria Gabriela Costa Lazaretti[1], Nelson Nunes Tenório Junior[1], Thaise Moser Teixeira [1]

[1]Mestrado em Gestão do Conhecimento nas Organizações – UniCesumar

mgc.lazaretti@gmail.com, nelson.tenorio@docentes.unicesumar.edu.br,

thaise.teixeira@docentes.unicesumar.edu.br

Abstract. *Knowledge has become increasingly important as a resource for organizations. In line with this, there arises the need for the classification and organization of knowledge bases in knowledge-oriented organizations. In this regard, ontologies support the process of structuring and classifying information, facilitating and simplifying the continuous data processing. The present work aims to propose a questionnaire for the validation of a domain ontology.*

1. Introduction

Knowledge is becoming an increasingly important resource for organizations in their pursuit of competitiveness and survival. This leads to the emergence of knowledge-driven organizations. Consequently, there is a need for the classification and organization of a company's knowledge bases. In this regard, ontologies aim to play a crucial role in structuring information, simplifying continuous data processing, and promoting interoperability among different applications [Almeida and Barbosa 2009, Chalmeta and Pazos 2015, Fritzsche et al. 2017, Larsen et al. 2017, Neuhaus et al. 2011, Roman et al. 2005]. A domain ontology provides a formal representation of a specific field and establishes consensus agreements on the meaning of terms used within that domain [Hepp et al. 2006]. High-quality domain ontologies are essential for fostering software interoperability and achieving precise modeling within a specific field of interest [Besheli 2018, Devi and Mittal 2016].

Over the past decade, numerous initiatives for the development of systems for domain ontology evaluation have emerged, highlighting the importance and relevance of the subject. Among these initiatives, we can mention Oops! [Poveda-Villalón et al. 2012], OntoCheck [Schober et al. 2012], NeOn [Keet et al. 2013], COLORE [Grüninger et al. 2012], OntoHub [Mossakowski et al. 2014], Linked Open Vocabularies [Vandenbussche et al. 2017], ROMULUS [Khan and Keet 2016], and Bioinformatics [Bodenreider 2018]. These models focus on creating libraries accessible to communities, with the goal of enabling these communities to access, evaluate, and keep the ontology up-to-date. Building upon these models, [McDaniel and Storey 2019] conducted a survey of terms and definitions related to the evaluation of domain ontologies.

The objective of this work is to develop a method for validating the quality of a domain ontology and, based on the analysis of terms identified by [McDaniel and Storey 2019], create a questionnaire for domain ontology subject matter experts to evaluate it, thereby ensuring the quality of the developed ontology.

The present paper is structured as follows. In the next section, we present related works on ontology quality. Section three outlines the methodology used to develop the questionnaire for validating a domain ontology. Section four presents the results of our research, and finally, in section five, we provide conclusions followed by references and an appendix.

2. Related Work

Over time, the field of domain ontology engineering has evolved significantly, and efforts to evaluate the quality of domain ontologies have also matured. According to [McDaniel and Storey 2019], numerous development and evaluation initiatives have emerged, making it challenging to examine them all. Figure 1 illustrates a timeline highlighting the most significant milestones in this context.

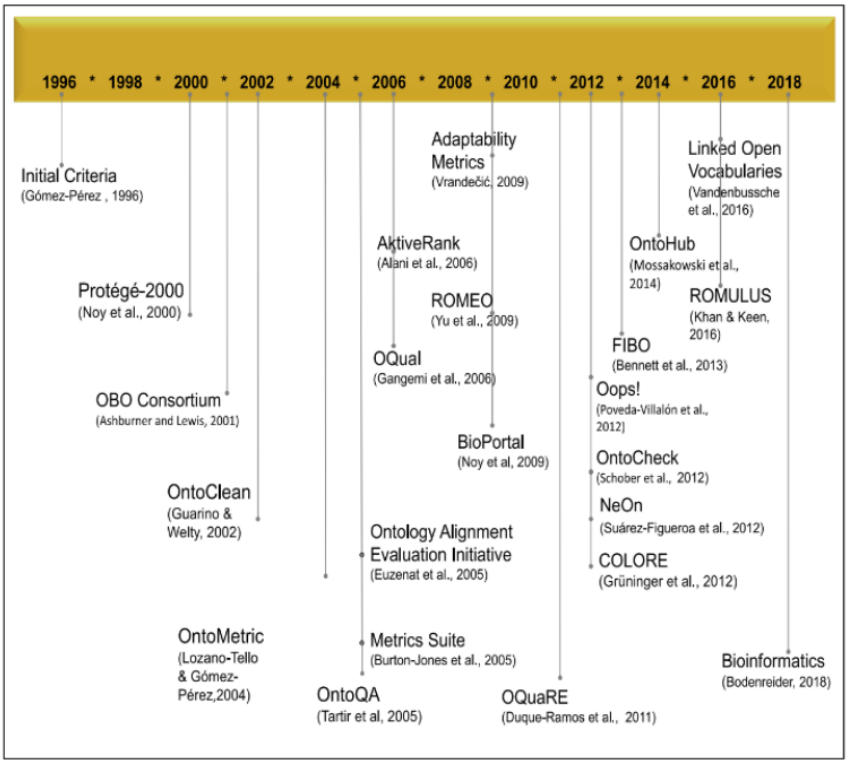

Figure 1. Timeline of domain ontology evaluation initiatives
[McDaniel and Storey 2019, p.70:6]

The study and survey conducted by the authors demonstrate that there is over 20 years of research focused on the evaluation of domain ontology quality. According to the authors, one of the initial methods involved (1) determining which quality attributes in ontologies should undergo evaluation and (2) creating metrics for this assessment. The subsequent logical phase involved the identification of errors in ontologies and their subsequent correction [McDaniel and Storey 2019].

In the study, 172 articles were surveyed, which were published in the last two decades and focused on the evaluation of ontology quality. The authors found that the majority of works in ontology evaluation tend to rely on a single method to determine quality. For example, the authors mentioned OntoClean [Guarino and Welty 2002]

and Oops [Poveda-Villalón et al. 2012], which assess errors and omissions in ontologies. COLORE [Grüninger et al. 2012], BioPortal [Noy et al. 2009], and OntoHub [Mossakowski et al. 2014, Codescu et al. 2017] focus on creating ontology libraries to enable the community to evaluate and keep ontologies up-to-date. OntoMetric [Lozano-Tello and Gómez-Pérez 2004], OntoQA [Tartir et al. 2010], and OQuaRE [Duque-Ramos et al. 2011] provide sets of metrics to obtain a comprehensive assessment of ontology quality [McDaniel and Storey 2019].

3. Method

A questionnaire was structured to validate a proposed ontology and was structured following the studies and definitions of terms related to domain ontology evaluation by the authors [Orme et al. 2006, Vrandečić 2009, Neuhaus et al. 2013, Gruber 1995, Yao et al. 2005, Gómez-Pérez 1996, Weber 2002, Hepp 2007, Maedche and Volz 2001, Stamper et al. 2000, Porzel and Malaka 2004] presented in Table 1.

3.1. Questionnaire Design

The questionnaire was structured with the aim of understanding whether the ontology meets the expectations and needs of product specialists. The questions have been organized in Google Forms, a tool that will be used to collect responses. The questions are categorized into four sections, as presented in Table 2.

The first section contains questions about the participant's profile, consisting of 3 multiple-choice questions regarding their job position and years of experience. The second section contains likert scale questions about the respondents' perception of the company's knowledge base, comprising 3 questions. The third section contains questions for evaluating the proposed ontology, consisting of nine likert scale questions aimed at understanding whether the ontology meets the quality requirements and one open-ended for feedback presented in Table 3. The fourth section aims to assess the quality of the developed questionnaire, with one multiple-choice question, two likert scale questions and two open-ended questions designed to understand the respondent's experience and whether there were any missing questions they would consider important to be included in the survey.

3.2. Data Collection

Employees from a software product development company for the financial market were invited to participate and respond to the questionnaire. The invitation, along with the link to the form, was sent through the company's internal social network, via corporate chat. The form link was shared with 41 people who are directly involved with the mentioned product, as they would have expertise in the subject covered by the ontology. The form included a video explaining the ontology, from its conception to its structuring and examples of its use for knowledge retrieval. To validate the questionnaire, 5 questions were developed, as presented below.

1. How long did it take you to respond to the questionnaire?
2. Do you consider this amount of time reasonable?
3. Were the questions relevant for you to evaluate the ontology?
4. Would you exclude any question? Why?

Table 1. Terms and Definitions Related to Domain Ontology Evaluation

Term		Citation	Definition
T1	Coupling	[Orme et al. 2006]	Assesses how well the modules work together in systems of ontologies
T2	Adaptability	[Vrandečić 2009]	Measures how well an ontology anticipates its future uses and whether it provides a secure foundation that is easily extendedand flexible enough to react predictably to small internal changes
T3	Craftsmanship	[Neuhaus et al. 2013]	Refers to whether the ontology is built carefully, including its syntactic correctness and consistent implementation
T4	Clarity	[Gruber 1995]	Refers to whether an ontology effectively communicates the intended meaning of its defined terms and contains objective definitions that are independent of a particular context
T5	Cohesion	[Yao et al. 2005]	Refers to the degree to which the elements of a module belong together
T6	Completeness	[Gómez-Pérez 1996]	Refers to whether an ontology has sufficiency in its definitions to all possible domains
T7	Conciseness	[Gómez-Pérez 1996]	Refers to the absence of redundancies including redundancies that could be inferred from its definitions and axioms
T8	Correctness	[Gómez-Pérez 1996]	Refers to whether the concepts, instances, relationships, and properties modeled correlate with those in the world being modeled
T9	Domain Ontology	[Weber 2002]	Is a conceptualization specific to a particular domain
T10	Expandability	[Gómez-Pérez 1996]	Refers to the ability of an ontology to be extended in order to describe specific application domains in a way that does not change its current definitions
T11	Expressiveness	[Hepp 2007]	Refers to an ontology's degree of detail
T12	Fitness	[Neuhaus et al. 2013]	Refers to whether the ontology meets the requirements of its intended use
T13	Intelligibility	[Neuhaus et al. 2013]	Refers to the ability of all users to understand the intended interpretation of the ontology elements
T14	Pruning	[Maedche and Volz 2001]	A means of reducing the size of an ontology or module by removing elements outside of a specific application domain
T15	Semantics	[Stamper et al. 2000]	Defined as the mapping between a sign and what it represents
T16	Task Fit	[Porzel and Malaka 2004]	Refers to the evaluation of an ontology in relation to its performance on a specific set of tasks

[McDaniel and Storey 2019, p. 70:4, 70:5]

5. Would you add any question? Why?

The form was available for respondents from September 25th to October 2nd. All data was kept confidential, and it is not possible to identify the participants based on the responses.

3.3. Analysis of the data

The data was exported to Excel format. Initially, the respondents' profiles were analyzed (position, tenure in the company, and duration in the position). Then, the evaluation of the questionnaire was analyzed.

4. Results

Based on the studies conducted by [McDaniel and Storey 2019], who collected, classified, and analyzed the main tools and methods for assessing the quality of domain ontologies,

Table 2. Questionnaire Overview

Section		Dimension	Goal	Description
S1	Background questions	Sample characteristics	Identifying the respondents' profile.	Multiple-choice questions related to the individual, such as: job position, length of time working in the company, length of time in the current position.
S2	KM	KM Perception	Understanding the perception of how to find information and knowledge within the company.	Likert scale questions related to the ease or difficulty of finding knowledge about the product.
S3	Ontology	Perception of the ontology	Understanding whether the modeled ontology contains the quality characteristics identified in the literature.	Nine Likert scale questions and one open-ended related to the developed domain ontology: analysis of classes, relationships, and instances.
S4	Questionnaire	Perception of the questionnaire.	Understanding whether the questionnaire is adequate or what needs to be changed.	One Multiple-choice question, two Likert scale questions and two open-ended questions related to the structure and content of the questionnaire and response time.

Source: Prepared by the authors, 2023

it was possible to create a structured questionnaire that addresses and considers 16 topics related to ontology quality. This mapping of terms and questions is presented in Table 3, which is available in the appendix of this work.

As a result, the questionnaire is capable of combining and evaluating a set of characteristics that have been demonstrated to be important and relevant for the quality and structure of an ontology, as discussed by various authors throughout this paper.

The questionnaire was answered by 16 individuals who work directly with the

Table 3. Questionnaire questions

Section	Question		Assessed term
S1	Q1	What is your job position in the company?	n/a
	Q2	How long have you been working at the company?	n/a
	Q3	How long have you been in your current position?	n/a
S2	Q4	Considering the software product I work on, I have difficulty finding information to acquire knowledge about it	n/a
	Q5	I believe that the software product is well-documented	n/a
	Q6	I consider that the knowledge base is well-organized and easy to find what I need	n/a
S3	Q7	Based on your knowledge of the product, was the mapping done adequately	T3, T4, T5, T7, T8, T9, T11, T13
	Q8	The product modules were adequately mapped in their entirety	T3, T4, T6, T7, T9, T13
	Q9	Is the test environment sufficient to represent the necessary environments for the product	T4, T6, T9, T13
	Q10	Is the production environment sufficient to represent the necessary environments for the product	T4, T6, T9, T13
	Q11	Were the operations of the product's account functionality described below adequately mapped in their entirety	T4, T6, T9, T13
	Q12	Were the operations of the product's QR Code functionality described below adequately mapped in their entirety	T4, T6, T9, T13
	Q13	Were the operations of the Transaction functionality described below adequately mapped in their entirety	T4, T6, T9, T13
	Q14	Adequate mapping has been done for the providers, in their entirety	T4, T6, T9, T13
	Q15	Considering the examples of ontology usage, I believe it will help me retrieve product knowledge when needed	T4, T9, T10, T11, T12, T13 T15, T16
	Q16	Would you like to leave any comments about the ontology?	T13, T14, T16
S4	Q17	How long did it take you to respond to the questionnaire?	n/a
	Q18	Do you consider it a reasonable amount of time?	n/a
	Q19	Were the questions relevant for you to be able to evaluate the ontology?	n/a
	Q20	Would you exclude any question? Why?	n/a
	Q21	Would you add any question? Why?	n/a

Source: Prepared by the authors, 2023

product studied for the ontology creation. The respondents' profiles are presented in Figure 1.

Figure 2(a) shows the respondents' positions. The majority work as Systems Analysts, accounting for 50% of the respondents. Figure 2(b) illustrates the duration the respondents have been in their positions, with 25% indicating they have been in their po-

sitions for up to 1 year and 62.5% for 1 to 3 years, indicating a majority with relatively little experience in their current positions. Figure 2(c) presents the tenure at the company, with 12.5% indicating up to 1 year, 62.5% from 1 to 3 years, 18.8% from 3 to 5 years, and 6.3% more than 5 years. This shows that despite their short tenure in their current positions, the majority of respondents have been with the company for more than 1 year.

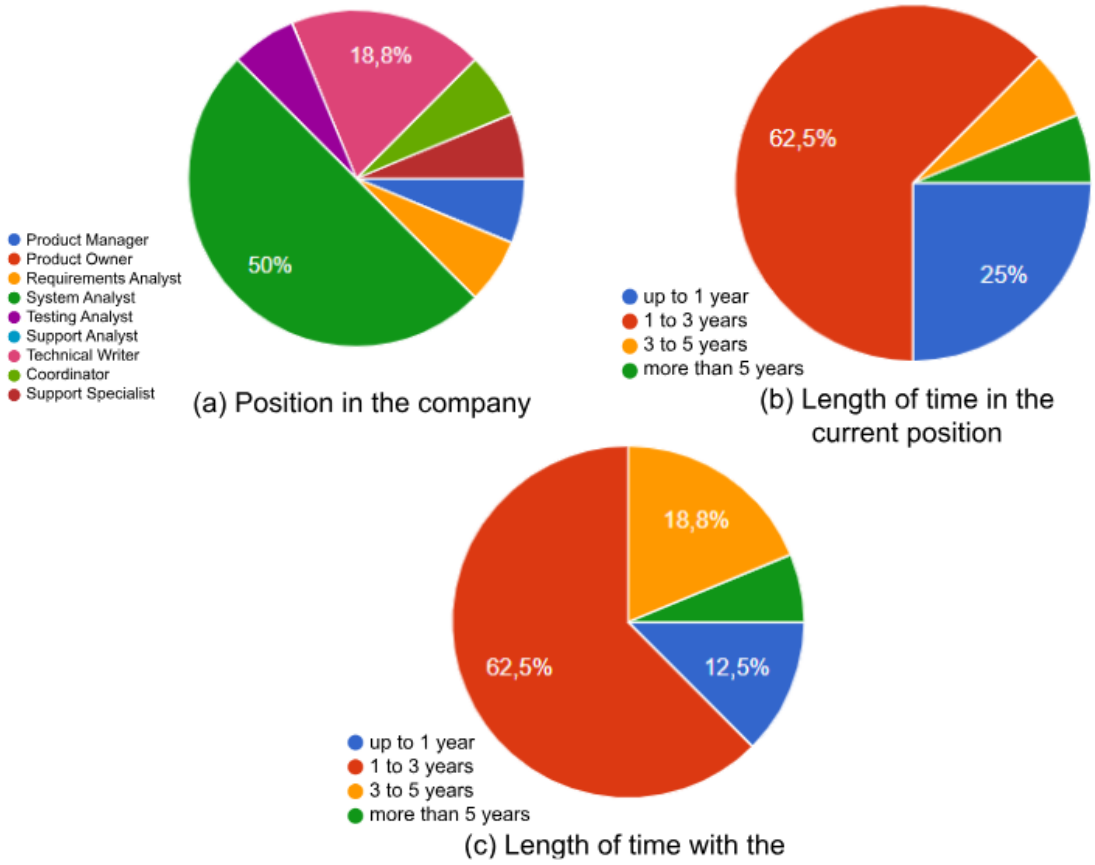

Figure 2. Profile of the participants
Source: Prepared by the authors, 2023

4.1. Proof of Concept Findings

The Proof of Concept of the questionnaire yielded some results that helped us understand its quality. For the analysis, it will be divided into 4 categories: response time, relevance of the questions, removed questions, and added questions.

Response time: The majority of participants (56.3%) reported taking 10 to 20 minutes to complete the questionnaire. 37.5% took 5 to 10 minutes, and only 6.3% took more than 20 minutes. When asked if the topic was appropriate, more than half agreed (50% agreed, and 31.3% strongly agreed).

Questions: When asked about the relevance of the questions to evaluate the ontology, the vast majority found them relevant, with 56.3% agreeing and 31.3% strongly agreeing. Only 12.5% remained neutral.

Removing questions: No participant indicated any question to be removed. Most found the questions relevant, providing feedback such as ”No. I found the questions

relevant for evaluating the adequacy of the ontology. They are appropriate to understand if the ontology meets the knowledge retrieval process."

Adding questions: One participant suggested more detailed questions, saying, "Perhaps I would add some more detailed points in the questions, without infringing on the product's intellectual aspects." Others considered the questions adequate and complete for ontology validation. In fact, one participant understood that "I believe the listed questions already serve the purpose of evaluating whether the created ontology facilitates the knowledge retrieval process. Adding more questions could make the form excessively long."

5. Conclusion

The research presented the construction and validation of a questionnaire aimed at evaluating a domain ontology. Respondents considered the questionnaire appropriate and relevant for ontology evaluation. None of the respondents suggested removing or adding any questions. With the development of the questionnaire, it will be possible to evaluate a developed domain ontology and understand if it is suitable for the identified domain and usage scenario.

Therefore, the proposed questionnaire will facilitate and contribute to the evaluation process of developed ontologies that follow a similar development process and have similar characteristics.

6. Acknowledgments

CAPES (Coordination for the Improvement of Higher Education Personnel) and the Postgraduate Program in Knowledge Management in Organizations at Cesumar University (Unicesumar) in the city of Maringá, PR, are acknowledged for providing the resources and means to carry out this research.

References

Almeida, M. B. and Barbosa, R. R. (2009). Ontologies in knowledge management support: A case study. *Journal of the American Society for Information Science and Technology*, 60(10):2032–2047.

Besheli, P. R. (2018). The pattern of patterns: What is a pattern in conceptual modeling? In *VMBO*, pages 99–106.

Bodenreider, O. (2018). Evaluating the quality and interoperability of biomedical terminologies april 2018.

Chalmeta, R. and Pazos, V. (2015). A step-by-step methodology for enterprise interoperability projects. *Enterprise Information Systems*, 9(4):436–464.

Codescu, M., Kuksa, E., Kutz, O., Mossakowski, T., and Neuhaus, F. (2017). Ontohub: A semantic repository engine for heterogeneous ontologies. *Applied Ontology*, 12(3-4):275–298.

Devi, M. S. and Mittal, H. (2016). Machine learning techniques with ontology for subjective answer evaluation. *arXiv preprint arXiv:1605.02442*.

Duque-Ramos, A., Fernández-Breis, J. T., Stevens, R., and Aussenac-Gilles, N. (2011). Oquare: A square-based approach for evaluating the quality of ontologies. *Journal of research and practice in information technology*, 43(2):159–176.

Fritzsche, D., Grüninger, M., Baclawski, K., Bennett, M., Berg-Cross, G., Schneider, T., Sriram, R., Underwood, M., and Westerinen, A. (2017). Ontology summit 2016 communique: Ontologies within semantic interoperability ecosystems. *Applied Ontology*, 12(2):91–111.

Gómez-Pérez, A. (1996). Towards a framework to verify knowledge sharing technology. *Expert Systems with applications*, 11(4):519–529.

Gruber, T. R. (1995). Toward principles for the design of ontologies used for knowledge sharing? *International journal of human-computer studies*, 43(5-6):907–928.

Grüninger, M., Hahmann, T., Hashemi, A., Ong, D., and Ozgovde, A. (2012). Modular first-order ontologies via repositories. *Applied Ontology*, 7(2):169–209.

Guarino, N. and Welty, C. (2002). Evaluating ontological decisions with ontoclean. *Communications of the ACM*, 45(2):61–65.

Hepp, M. (2007). Possible ontologies: How reality constrains the development of relevant ontologies. *IEEE Internet Computing*, 11(1):90–96.

Hepp, M., Bachlechner, D., and Siorpaes, K. (2006). Ontowiki: community-driven ontology engineering and ontology usage based on wikis. In *Proceedings of the 2006 international symposium on Wikis*, pages 143–144.

Keet, C. M., Suárez-Figueroa, M. C., and Poveda-Villalón, M. (2013). The current landscape of pitfalls in ontologies.

Khan, Z. C. and Keet, C. M. (2016). Romulus: The repository of ontologies for multiple uses populated with mediated foundational ontologies. *Journal on Data Semantics*, 5(1):19–36.

Larsen, K. R., Michie, S., Hekler, E. B., Gibson, B., Spruijt-Metz, D., Ahern, D., Cole-Lewis, H., Ellis, R. J. B., Hesse, B., Moser, R. P., et al. (2017). Behavior change interventions: the potential of ontologies for advancing science and practice. *Journal of behavioral medicine*, 40:6–22.

Lozano-Tello, A. and Gómez-Pérez, A. (2004). Ontometric: A method to choose the appropriate ontology. *Journal of Database Management (JDM)*, 15(2):1–18.

Maedche, A. and Volz, R. (2001). The ontology extraction & maintenance framework text-to-onto. In *Proc. Workshop on Integrating Data Mining and Knowledge Management, USA*, pages 1–12.

McDaniel, M. and Storey, V. C. (2019). Evaluating domain ontologies: clarification, classification, and challenges. *ACM Computing Surveys (CSUR)*, 52(4):1–44.

Mossakowski, T., Kutz, O., and Codescu, M. (2014). A semantic repository for heterogeneous ontologies.

Neuhaus, F., Florescu, E., Galton, A., Gruninger, M., Guarino, N., Obrst, L., Sanchez, A., Vizedom, A., Yim, P., and Smith, B. (2011). Creating the ontologists of the future. *Applied Ontology*, 6(1):91–98.

Neuhaus, F., Vizedom, A., Baclawski, K., Bennett, M., Denny, M., Grüninger, M., Hashemi, A., Longstreth, T., Obrst, L., Ray, S., et al. (2013). Towards ontology evaluation across the life cycle.

Noy, N. F., Shah, N. H., Whetzel, P. L., Dai, B., Dorf, M., Griffith, N., Jonquet, C., Rubin, D. L., Storey, M.-A., Chute, C. G., et al. (2009). Bioportal: ontologies and integrated data resources at the click of a mouse. *Nucleic acids research*, 37(suppl_2):W170–W173.

Orme, A. M., Tao, H., and Etzkorn, L. H. (2006). Coupling metrics for ontology-based system. *IEEE software*, 23(2):102–108.

Porzel, R. and Malaka, R. (2004). A task-based approach for ontology evaluation. In *ECAI Workshop on Ontology Learning and Population, Valencia, Spain*, pages 1–6. Citeseer Valencia, Spain.

Poveda-Villalón, M., Suárez-Figueroa, M. C., and Gómez-Pérez, A. (2012). Validating ontologies with oops! In *Knowledge Engineering and Knowledge Management: 18th International Conference, EKAW 2012, Galway City, Ireland, October 8-12, 2012. Proceedings 18*, pages 267–281. Springer.

Roman, D., Keller, U., Lausen, H., De Bruijn, J., Lara, R., Stollberg, M., Polleres, A., Feier, C., Bussler, C., and Fensel, D. (2005). Web service modeling ontology. *Applied ontology*, 1(1):77–106.

Schober, D., Tudose, I., Svatek, V., and Boeker, M. (2012). Ontocheck: verifying ontology naming conventions and metadata completeness in protégé 4. In *Journal of biomedical semantics*, volume 3, pages 1–10. BioMed Central.

Stamper, R., Liu, K., Hafkamp, M., and Ades, Y. (2000). Understanding the roles of signs and norms in organizations-a semiotic approach to information systems design. *Behaviour & information technology*, 19(1):15–27.

Tartir, S., Arpinar, I. B., and Sheth, A. P. (2010). Ontological evaluation and validation. *Theory and applications of ontology: Computer applications*, pages 115–130.

Vandenbussche, P.-Y., Atemezing, G. A., Poveda-Villalón, M., and Vatant, B. (2017). Linked open vocabularies (lov): a gateway to reusable semantic vocabularies on the web. *Semantic Web*, 8(3):437–452.

Vrandečić, D. (2009). Ontology evaluation. In *Handbook on ontologies*, pages 293–313. Springer.

Weber, R. A. (2002). Ontological issues in accounting information systems.

Yao, H., Orme, A. M., and Etzkorn, L. (2005). Cohesion metrics for ontology design and application. *Journal of Computer science*, 1(1):107–113.