

“Ontology engineering” Course Options

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Hereby the somewhat lengthy answer to your question about possible contents for a course on “Ontology engineering”. The first part is about options what you actually might be looking for, whereas the second part consists of an annotated list of references to courses and possible course material.

1 On aims and topics

First of all, there is no single course that covers all topics, neither at UniBz nor anywhere else. Put differently, people group different topics under the term “ontology engineering” and cover those topics to a greater or lesser extent, or not at all¹; hence, you have to decide what you really want with a course on ontology engineering. A selection of possible learning outcomes for the prospective students are to:

- A. develop domain ontologies;
- B. develop integrated, ontology-based or ontology-mediated, applications;
- C. develop tools for ontology development (such as editors and ontology learning tools using, e.g., text mining and ‘upgrading’ of conceptual data models in UML or ER);
- D. investigate ontology languages and their computational properties;
- E. investigate foundational modelling aspects (such as core ontologies, characteristics of principal relations, ontology design patterns).

Items A and B focus more on the usage component, item C could be borderline science-engineering, whereas D and E focus on adding novel knowledge to the current body of scientific knowledge; roughly: educating capable engineers vs scientists.

In addition, one has to take into account the depth of knowledge aimed at with these possible learning outcomes (BSc-, MSc- or PhD-course levels, user-training, ...).

Unsurprisingly, a course in “ontology engineering” will look different depending on the desired learning outcomes, but also on the prior knowledge of the students. To cover all aspects of ontology engineering one ends up with a *very* large course, and it might be useful to split it up so as to better serve the various aims of different interests of the students. The list of principal topics is:

1. Logic (propositional and predicate) and Artificial Intelligence (including at least knowledge bases);
2. Ontology (philosophy), with foundational aspects, such as categories of entities, ontological commitments, properties of relations;
3. Ontology languages (such as OWL, WSML, DL-Lite, EL);
4. Semantic Web technologies (OWL, RDF, SPARQL, XML, etc.) and their usage (with editors, rule engines, reasoners etc. and scope of applications);
5. Modelling methodologies (such as reuse and enhancement of methodologies for conceptual modelling and methontology);
6. Project-oriented topics that integrate theory and engineering (when to use what, why, and how);

In addition, there are further specialisation topics, such as:

- i. ontology-based data access and integration, combining rules with ontologies, and computational linguistics;

¹ and this text likely suffers from some bias as well. The course and literature references are sample texts of the kind of material, but are certainly not the only sources around

- ii. language extensions, such as fuzzy logic and temporal logics;
- iii. internal workings of automated reasoners (model checkers, theorem provers), i.e., with their algorithms and optimizations, generating explanations;
- iv. modularisation, distributed reasoning, granularity, abstraction, contexts, ontology integration;
- v. subject domain specific peculiarities (e.g., life sciences, the legal domain, agriculture);
- vi. auxiliary technologies, such as ontology learning with text mining, machine learning, conceptual model reuse, reverse engineering, and upgrading thesauri.

The current state of items 3, 4 and i-vi is more in flux than 1, 2 and the skills learned with 6: 3 & 4 because standards tend to be updated every few years, and i-vi because all or part of it are still active research areas.

2 UniBz and other reference and course material

2.1 UniBz

The course material offered by UniBz in this university year ('08/'09) does not cover all of items 2, 5, 6, ii-vi, but from the '09/'10 year, more of 6 and ii-vi will be added. On the other hand, it does cover additional foundations, such as Foundations in Databases, that are useful both for a more comprehensive understanding and to enable advancing the current state of the art.

The current relevant courses that contribute to successful ontology engineering directly are those in the advanced tracks of the European Masters in Computational Logic² and, to a lesser extent, the European Masters in Language and Communication Technologies³. More specifically, and with the links to the online course material (URLs of official course description and reference material, respectively):

- Knowledge Representation by Enrico Franconi: the [course description](#)
- Knowledge bases and databases by Diego Calvanese: the [course description](#) and material <http://www.inf.unibz.it/~calvanese/teaching/08-09-kbdb/>
- Computational Logic by Davide Martinenghi: the [course description](#) and material <http://home.dei.polimi.it/martinen/courses/c12009/CompLog2009.html>
- Semantic Web technologies by Jos de Bruijn: the [course description](#) and material <http://www.inf.unibz.it/~debruijn/teaching/swt/>
- Formal Methods by Alessandro Artale: the [course description](#) and material <http://www.inf.unibz.it/~artale/FM/fm.htm>
- Theory of computing by Diego Calvanese: the [course description](#) and material <http://www.inf.unibz.it/~calvanese/teaching/08-09-tc/>
- Non-classical Logics by Rosella Gennari: the [course description](#) and material <http://www.inf.unibz.it/~gennari/index.php?page=NL>
- Computational Linguistics by Raffaella Bernardi: the [course description](#) and material <http://www.inf.unibz.it/~bernardi/Courses/CompLing/08-09.html>

Note that logic and AI are already covered in our BSc courses⁴ and thus assumed to be known by [prerequisite for] the students.

We also have material of some relevant tutorials—i.e., crash-courses—given elsewhere, such as:

- TONES Tutorial on Reasoning for Ontology Engineering and Usage, held at the 7th International Semantic Web Conference (ISWC 2008). Karlsruhe, Germany, October 26-30, 2008. <http://owl.cs.manchester.ac.uk/2008/iswc-tones/>
- Diego Calvanese's recent tutorials:

² <http://www.computational-logic.eu/home.php>

³ <http://www.inf.unibz.it/mcs/lct/>

⁴ https://www.inf.unibz.it/courses/index.php?option=com_content&task=view&id=9080&Itemid=54

- Course on Query Processing in Data Integration, held as part of the Bolzano - Innsbruck - Trento (BIT) PhD Summer School. Bressanone. July 7-11, 2006. <http://www.inf.unibz.it/~calvanese/teaching/05-06-data-integration/>
- Tutorial on Ontology-based Data Access, held at the 6th International Semantic Web Conference (ISWC 2007). Busan, Korea, November 11-15, 2007. <http://www.inf.unibz.it/~calvanese/teaching/ISWC-2007-tutorial-obda/>
- Maria Keet’s recent tutorials:
 - Representing and reasoning over a taxonomy of part-whole relations. Mini Ontology Winter School (MOWS 2008), Knowledge System Group, Meraka Institute, 1-11 July 2008, Pretoria, South Africa. <http://www.meteck.org/files/PartspresMOWS08.pdf>
 - Semantic Web for the Life Sciences. Guest lecture d.d. 23-5-2007 as part of the course ‘Semantic Web Technologies’, Free University of Bozen-Bolzano, Italy. <http://www.meteck.org/files/SWLS23may07-handout.pdf>
 - Introduction to part-whole relations: mereology, conceptual modelling and mathematical aspects. Tutorial given on 23-10-2006 at the KRDB Research Centre, Free University of Bozen-Bolzano, Italy. <http://www.meteck.org/files/KRDB06-3.pdf>
- Temporal Knowledge and Ontologies by Alessandro Artale – PhD and MSc Tutorial <http://www.inf.unibz.it/~artale/temp-er.pdf>
- Description Logics by Enrico Franconi <http://www.inf.unibz.it/~franconi/dl/course/>
- Slides of 12 3-hour tutorials for MSc/PhD level, held in 2006: <http://www.inf.unibz.it/krdp/krdp-sem/index-2006.php>
- KRDB Spring School 2008 (MSc), with slides: <http://www.inf.unibz.it/krdp/school/2008/>

Further in-depth education goes through internships, projects, and theses done by the students in the line of investigation pursued by the members⁵ of the KRDB group⁶.

2.2 Additional references

Regarding item 2 (Ontology), some sample references and courses elsewhere are the ontology courses by the Laboratory of Applied Ontology⁷ developed by Nicola Guarino and his colleagues and its ‘counterpart’ by the US National Centre of Biomedical Ontology⁸, which focus on topics like foundational ontologies such as DOLCE [1], BFO, RO [2], fundamental modelling issues such as the part-whole relation [3,4,5], and peculiarities of several subject domains.

For ontology languages (item 3), the DL Handbook [6] is still the main reference (or the 2008 version, which differs little; [description](#); pdf files available upon request), which, however, is not a text book considered to be suitable for independent learning; some course material in addition to the ones cited above are online [here](#). There are various subsets of references for the different DL language families, which I can compile upon request.

Details about ontology design methodologies (item 5) are better asked at Oscar Corcho, although we do have experiences in that area concerning specific methods, both regarding tools such as icom [7] and development of domain ontologies for sign language, ecology [8], and disabilities [9], among others, practical ‘guidelines’ such as [10], and other test results [11].

The specialisation topic of ontology-based data access (item i), i.e., linking concepts and relations in an ontology to data in the database, is one of the active research areas where people of the KRDB group added to the theory (DL-Lite languages and queries [12,13,14]), technology (QuOnto reasoner⁹, OBDA plugins for Protégé and the NeOn toolkit [15,16,17] ontology development environ-

⁵ See their respective home pages via [this page](#), and the [list of publications](#) for recent research foci.

⁶ <http://www.inf.unibz.it/krdp/>

⁷ 13 courses, with slides and/or related material through <http://www.loa-cnr.it/Teaching.html>

⁸ http://ontology.buffalo.edu/smith/Ontology_Course.html

⁹ <http://www.dis.uniroma1.it/~quonto/>

ments), and experimentation [11]. Regarding rules, a good basis is given by Riccardo Rosati [18] (pdf) and application-oriented solutions are expected to be developed within the ONTORULE project¹⁰.

For fuzzy ontology languages and reasoners, the website of Umberto Straccia is the best place to start¹¹, which also contains tutorial material of the ReasoningWeb Summer school¹². On the other hand, for temporal issues, there is a lot in logics proper and in temporal databases, but thus far little has made it into the practical ontology engineering domain; two basic references w.r.t. DL and temporal & modelling/ontologies are [19,20] but more is in the pipeline.

I can compile further references for items iii-vi (e.g. [21] for iv), but to give a targeted list of mainly references and the odd set of slides of mini-tutorials, it would be useful first to know which informatics topics take precedence so that I can filter out the irrelevant references.

References

1. Masolo, C., Borgo, S., Gangemi, A., Guarino, N., Oltramari, A.: Ontology library. WonderWeb Deliverable D18 (ver. 1.0, 31-12-2003). (2003) <http://wonderweb.semanticweb.org>.
2. Smith, B., Ceusters, W., Klagges, B., Köhler, J., Kumar, A., Lomax, J., Mungall, C., Neuhaus, F., Rector, A.L., Rosse, C.: Relations in biomedical ontologies. *Genome Biology* **6** (2005) R46
3. Keet, C.M., Artale, A.: Representing and reasoning over a taxonomy of part-whole relations. *Applied Ontology – Special issue on Ontological Foundations for Conceptual Modeling* **3**(1-2) (2008) 91–110
4. Artale, A., Guarino, N., Keet, C.M.: Formalising temporal constraints on part-whole relations. In Brewka, G., Lang, J., eds.: 11th International Conference on Principles of Knowledge Representation and Reasoning (KR'08), AAAI Press (2008) Sydney, Australia, September 16-19, 2008.
5. Varzi, A.C.: Mereology. In Zalta, E.N., ed.: *Stanford Encyclopedia of Philosophy*. Fall 2004 edn. Stanford (2004) <http://plato.stanford.edu/archives/fall2004/entries/mereology/>.
6. Baader, F., Calvanese, D., McGuinness, D.L., Nardi, D., Patel-Schneider, P.F., eds.: *The Description Logics Handbook – Theory and Applications*. Cambridge University Press (2003)
7. Fillottrani, P., Franconi, E., Tessaris, S.: The new ICOM ontology editor. In: 19th International Workshop on Description Logics (DL'06). (2006) Lake District, UK. May 2006.
8. Keet, C.M.: Factors affecting ontology development in ecology. In Ludäscher, B., Raschid, L., eds.: *Data Integration in the Life Sciences 2005 (DILS2005)*. Volume 3615 of LNBI., Springer Verlag (2005) 46–62 San Diego, USA, 20-22 July 2005.
9. Keet, C.M., Alberts, R., Gerber, A., Chimamiwa, G.: Enhancing web portals with Ontology-Based Data Access: the case study of South Africa's Accessibility Portal for people with disabilities. In: *Proceedings of the Fifth OWL: Experiences and Directions (OWLED 2008)*. (2008) Karlsruhe, Germany, 26-27 October 2008.
10. Keet, C.M., Rodríguez, M.: Toward using biomedical ontologies: trade-offs between ontology languages. In: *AAAI 2007 Workshop Semantic eScience (SeS 2007)*. Volume WS-07-11 of AAAI Technical Report., AAAI (2007) 65–68 23 July 2007, Vancouver, Canada.
11. Alberts, R., Calvanese, D., Giacomo, G.D., Gerber, A., Horridge, M., Kaplunova, A., Keet, C.M., Lembo, D., Lenzerini, M., Milicic, M., Möller, R., Rodríguez-Muro, M., Rosati, R., Sattler, U., Suntisrivaraporn, B., Stefanoni, G., Turhan, A.Y., Wandelt, S., Wessel, M.: Analysis of test results on usage scenarios. Deliverable TONES-D27 v1.0, TONES Project (Oct. 10 2008)
12. Calvanese, D., Giacomo, G.D., Lembo, D., Lenzerini, M., Rosati, R.: Tractable reasoning and efficient query answering in description logics: The DL-Lite family. *Journal of Automated Reasoning* **39**(3) (2007) 385–429
13. Calvanese, D., De Giacomo, G., Lembo, D., Lenzerini, L., Rosati, R.: EQL-Lite: Effective first-order query processing in description logics. In: *Proc. of IJCAI 2007*. (2007) 274–279
14. Poggi, A., Lembo, D., Calvanese, D., De Giacomo, G., Lenzerini, M., Rosati, R.: Linking data to ontologies. *J. on Data Semantics* **X** (2008) 133–173

¹⁰ <http://ontorule-project.eu/>

¹¹ <http://faure.isti.cnr.it/~straccia/>

¹² Managing Uncertainty and Vagueness in Description Logics, Logic Programs and Description Logic Programs. [chapter](#) and [slides](#)

15. Rodriguez-Muro, M., Lubyte, L., Calvanese, D.: Realizing Ontology Based Data Access: A plug-in for Protégé. In: Proc. of the Workshop on Information Integration Methods, Architectures, and Systems (IIMAS 2008), IEEE Computer Society (2008)
16. Poggi, A., Rodriguez, M., Ruzzi, M.: Ontology-based database access with DIG-Mastro and the OBDA Plugin for Protégé. In Clark, K., Patel-Schneider, P.F., eds.: Proc. of the OWL: Experiences and Directions 2008 (OWLED 2008 DC). (2008) Washington DC, USA. April, 2008.
17. Calvanese, D., Rodríguez, M.: Towards an open framework for Ontology Based Data Access with Protégé and DIG 1.1. In: Proceedings of the 5th Workshop on OWL: Experiences and Directions (OWLED 2008), Karlsruhe, Germany (October 2008)
18. Rosati, R.: Integrating ontologies and rules: semantic and computational issues. In: ReasoningWeb Summer School Proceedings. Volume 4126 of LNCS., Springer (2006) 128–151
19. Artale, A., Franconi, E., Wolter, F., Zakharyashev, M.: A temporal description logic for reasoning about conceptual schemas and queries. In Flesca, S., Greco, S., Leone, N., Ianni, G., eds.: Proceedings of the 8th Joint European Conference on Logics in Artificial Intelligence (JELIA-02). Volume 2424 of LNAI., Springer Verlag (2002) 98–110
20. Artale, A., Parent, C., Spaccapietra, S.: Evolving objects in temporal information systems. *Annals of Mathematics and Artificial Intelligence* **50**(1-2) (2007) 5–38
21. Keet, C.M.: A Formal Theory of Granularity. Phd thesis, KRDB Research Centre, Faculty of Computer Science, Free University of Bozen-Bolzano, Italy (April 2008)