

Semantic Technologies and Learning

Thanassis Tiropanis, Hugh C. Davis, Stefano A. Cerri

▶ To cite this version:

Than assis Tiropanis, Hugh C. Davis, Stefano A. Cerri. Semantic Technologies and Learning. Encyclopedia of the Sciences of Learning, Part 19, Springer, pp.3029-3032, 2012, 10.1007/978-1-4419-1428-6_1096. lirmm-00670658

HAL Id: lirmm-00670658 https://hal-lirmm.ccsd.cnrs.fr/lirmm-00670658

Submitted on 16 Feb 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Metadata of the chapter that will be visualized online

Chapter Title	Semantic Technologies and Learning		
Copyright Year	2011		
Copyright Holder	Springer Science + Business Media, LLC		
Corresponding Author	Family Name	Tiropanis	
	Particle		
	Given Name	Thanassis	
	Suffix		
	Division	Learning Societies Lab, School of Electronics and Computer Science	
	Organization	University of Southampton	
	Address	University Road, Southampton, SO17 1BJ, United Kingdom	
	Email	tt2@ecs.soton.ac.uk	
Author	Family Name	Davis	
	Particle		
	Given Name	Hugh C.	
	Suffix		
	Division	Learning Societies Lab, School of Electronics and Computer Science	
	Organization	University of Southampton	
	Address	University Road, Southampton, SO17 1BJ, United Kingdom	
	Email	hcd@ecs.soton.ac.uk	
Author	Family Name	Cerri	
	Particle		
	Given Name	Stefano A.	
	Suffix		
	Division	LIRMM: Laboratory of Informatics, Robotics and Microelectronics	
	Organization	University Montpellier2 & CNRS	
	Address	161 rue Ada, 34095, Montpellier Cedex 5, France	
	Email	cerri@lirmm.fr	

Comp. by: GOMATHI K Stage: Galleys Chapter No.: 1096 Title Name: ESL Page Number: 0 Date:4/3/11 Time:07:10:10

S

Semantic Technologies and Learning

- 4 THANASSIS TIROPANIS¹, HUGH C. DAVIS¹, STEFANO A. CERRI²
- ⁵ ¹Learning Societies Lab, School of Electronics and
- 6 Computer Science, University of Southampton,
- 7 Southampton, United Kingdom
- ⁸ ²LIRMM: Laboratory of Informatics, Robotics and
- 9 Microelectronics, University Montpellier2 & CNRS,
- 10 Montpellier Cedex 5, France

11 Synonyms

12 Knowledge representation and reasoning and learning;

13 Linked data and learning; Semantic web and learning

14 **Definition**

Semantic technologies provide for the expression of 15 meaning of resources such as content, software, systems, 16 people, and communities in machine processable formats 17 with the help of ontologies. Ontologies provide the vocab-18 ulary for describing resources and their relationships 19 (Gruber 1993; Musen 1992). Based on the meaning of 20 resources, semantic technologies can draw conclusions 21 and enable better resource discovery and matching. 22 In a learning context, the potential of semantic 23

technologies translates to a number of affordances. The 24 25 types of resources involved in formal or informal learning environments could include learners, teachers, software, 26 services and content. Given the description (or annota-27 tion) of these resources with the help of ontologies, it is 28 possible to support more efficient discovery of learning 29 30 resources, sequencing of relevant learning material, adaptation of learning experiences to match learner profiles, 31 formation of groups for teaching learning activities, 32 collaborative construction of knowledge, recommenda-33 tion of learning resources and activities, and assessment. 34 A number of ontologies are developed in the learning 35 domain in order to support these applications with the 36

37 help of reasoning software.

Theoretical Background

38

Semantic technologies for learning draw from work in 39 Knowledge Representation and Reasoning and have been 40 significantly influenced by developments in the Semantic 41 Web community (Berners-Lee et al. 2001). The Semantic 42 Web vision has been considered "inevitable" and its 43 impact on education significant (Ohler 2008). 44

With the help of ontologies, semantic technologies can 45 support knowledge representation and reasoning. There 46 are a number of ontology languages to address the tradeoff 47 between how expressive an ontology language is and the 48 performance of reasoning based on resources annotated 49 with this ontology language. Resource descriptions in 50 more expressive ontology languages could potentially let 51 us perform advanced reasoning and draw more conclusions about resources, at the cost, however, of increased 53 computation and potentially reduced performance. 54

For example, some ontology languages let us use 55 transitive properties when describing how resources relate 56 to each other, which can provide for more powerful rea- 57 soning. Consider an ontology for the domain of language 58 education. We could identify concepts such as student and 59 class and relationships that express that a student attends 60 one class only or that a student is a classmate of another 61 student; one could also specify that the relationship "is 62 a classmate of "its transitive (i.e., if A is a classmate of 63 B and B is a classmate of C then A is a classmate of C). 64 Given this ontology, one can annotate (mark up) specific 65 resources as instances of ontology concepts. For example, 66 one could mark up each of "Alice," "Bob," and "Eve" as 67 instances of a student and "French" as an instance of a class; 68 one could also state that "Alice" is a classmate of "Bob," that 69 "Bob" is a classmate of "Eve," and that "Eve" attends 70 "French." Given this annotation and the ontology, it is 71 possible to draw conclusions with the help of software; in 72 this example, software could infer that "Alice" attends 73 "French" and that "Alice" is a classmate of "Eve" even if 74 this information is not explicitly stated in the annotation. 75

The power of knowledge representation and reasoning 76 bears significant promise for learning. In addition, the 77 well-formed description of resources with the use of lightweight or more expressive ontologies bears potential for 79 interoperability and data integration. This has led to 80

Norbert Seel (ed.), Encyclopedia of the Sciences of Learning, DOI 10.1007/978-1-4419-1428-6, © Springer Science+Business Media, LLC 2011 Semantic Technologies and Learning

81 research on the use of semantic technologies in a number

82 of areas related to learning.

2

83 Semantic Technology Affordances

The promise of semantic technologies in learning has been identified as an important aspect of Technology Enhanced Learning (TEL) in both formal and informal learning settings. The ability of semantic technologies to match people, content, and communities that are involved in learning processes is central in all these areas.

Matching learners to learning resources has led to 90 work on the integration of semantic technologies Learning 91 Management Systems (LMS), Learning Content Manage-92 ment Systems (LCMS), or Virtual Learning Environments 93 (VLE). The role of semantic technologies in these domains 94 is on discovering, sequencing, or adapting learning mate-95 rial based on the learner profile and learning outcomes. 96 Semantic technologies have been considered in the context 97 of collaborative building of knowledge and learning mate-98 rial by means of collaborative ontology building, topic 99 maps and semantic wikis. Collaborative ontology building 100 tools have also been developed to that end. 101

The use of semantic technologies to match learners to 102 103 other learners or teachers has been considered in groupformation systems in formal learning and informal learn-104 ing settings. In vocational training, semantic technologies 105 have been proposed to form groups of learners with 106 similar or supplementary competencies. In informal 107 learning, successfully matching learners based on their 108 profiles and their learning objectives using semantic 109 technologies has been pursued. 110

Another significant advantage of semantic technolo-111 gies is in matching content and people involved in learn-112 ing processes on a large scale: a larger pool of people and 113 content increases the chances of accurate matching. In this 114 respect, the semantic description of resources available in 115 repositories of reference material has been used for 116 advanced content discovery. Semantic applications to 117 support critical thinking and argumentation by enabling 118 the discovery of material in support or against a certain 119 argument are also being explored. At the same time, 120 aggregating and processing information about people 121 and their activity using semantic technologies has led to 122 work on expert matching tools and query answering. 123 Ontologies for describing relationships among people 124 such as the Friend-of-a-Friend (FOAF) ontology enable 125 additional tools on discovering people and supporting 126 informal learning processes. 127

Semantic technologies can support a number of processes in formal education institutions such as assessment.
In the environment of assessment semantic technologies

can help in preparing appropriate assessment material 131 that matches certain assessment criteria or in the analysis 132 of text that is submitted as part of assessment; there are 133 examples of use of semantic technologies for both summative and formative assessment. 135

Semantic technologies can also support well-formed 136 description of resources in a formal education environment and address interoperability and data integration 138 requirements inside and across education institutions. In 139 the context of formal education, the data interoperability 140 and integration affordances of semantic technologies can 141 support efficient systems for curriculum design, development of learning material, and collaboration among the 143 people involved in teaching and learning activities. 144

145

Building Semantic Technologies

Different approaches can be followed when it comes to 146 developing semantic technologies in a specific domain. 147 One can consider a top-down approach where the use of 148 an ontology or a set of ontologies are agreed first before 149 the annotation of resources and the deployment of appli- 150 cations. An alternative approach gives priority to exposing 151 data sources using lightweight vocabularies first, in order 152 to enable data interoperability and integration before 153 considering more complex ontologies in the context of 154 specific applications. The latter view is central in the 155 linked data movement (http://linkeddata.org/), which 156 proposes practices for exposing and connecting structured 157 data on the Web (Bizer et al. 2009). The Linked Data 158 movement supports the exposure of data sources in light- 159 weight vocabularies such as RDF (http://www.w3.org/ 160 RDF/) in order to allow for the emergence of intelligent 161 applications that will make use of the exposed data. 162

The value of semantic technologies and linked data in 163 terms of well-formed description of resources, data 164 interoperability, and data integration in the UK higher 165 education sector has been highlighted in a number of 166 reports (Tiropanis et al. 2009). The types of semantic 167 technologies that are related to learning and which can 168 benefit from the linked data approach include: 169

- Collaborative authoring and annotation tools
- Searching and matching tools based on linked data 171 resources (e.g., expert finders)
 172
- Repositories and VLEs that import or export their data 173 in linked data formats to support learning resource 174 discovery 175

In parallel to the Semantic Web vision, there are proposals for a *Pragmatic Web* (http://www.pragmaticweb. 177 info), in which the description of the meaning of resources 178 is based not just on the semantic constructs and their 179

227

238

180 relations as defined in ontologies, but also on the context

- in which resources are found and used. This contextual 181
- information could provide for more accurate mechanisms 182
- for learning resource discovery and use. 183

Important Scientific Research and Open 184 Questions

185

- Research on semantic technologies in learning has been 186 developing in several directions. A non-exhaustive list of 187 such directions and open research questions includes: 188
- Collaborative knowledge representation and mainte-189 nance in learning environments 190
- Supporting personal and group knowledge construc-191 . tion with semantic technologies 192
- Establishing the underpinning pedagogy of semantic 193 . applications or introducing pedagogy in semantic 194 applications 195
- Knowledge extraction on resources related to learning 196 .
- Transition from taxonomies and hierarchies to more 197 expressive ontologies for learning 198
- 199 Semantic applications for critical thinking and argumentation 200
- Exploring the potential of semantic technologies for 201 exploratory learning and problem-based learning 202
- Investigating the potential of sharing and combining 203 linked data inside or across educational institutions 204
- Semantic technologies to capture and enhance infor-205 mal learning processes 206

There are of systems that can support personal or 207 collaborative knowledge construction, which are often 208 Wiki-based or Topic-map based. In many cases, the 209 constructed knowledge is not available in machine 210 processable formats or formats that are appropriate for 211 integration with other relevant applications. This opens 212 siginificant questions on the feasibility, scalability, and 213 efficiency of semantic technology based approaches to 214 learning resource authoring and to data interoperability 215

and integration for learning systems. In addition, the 216 potential of semantic technologies to support pedagogy 217 technology-enhanced learning requires further 218 in research. Semantic applications seem promising in 219 supporting critical thinking and argumentation given the 220 availability of relevant resources and applications. 221 Applications that combine resources described using 222 lightweight vocabularies on a large scale, across educa- 223 tional institutions and organizations, could potentially 224 support novel processes for formal, informal, exploratory, 225 and problem-based learning. 226

Cross-References

 Collaborative Knowledge Building 	228
► Knowledge Acquisition: Constructing Meaning from	229
Multiple Information Sources	230
 Knowledge Organization 	231
 Knowledge Representation 	232
 Ontology and Semantic Web 	233
 Ontology Development and Learning 	234
 Ontology of Learning Objects Repository for 	235
Knowledge Sharing	
Semantic Networks to Support Learning	237

References

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The Semantic web.	239
Scientific American, 284(5), 29–37.	240
Bizer, C., Heath, T., & Berners-Lee, T. (2009). Linked data-the story so far.	241
International Journal on Semantic Web and Information Systems, 5(3),	242
1–22.	243
Gruber, T. R. (1993). A translation approach to portable ontology spec-	244
ification. Knowledge Acquisition, 5, 199–220.	245
Musen, M. A. (1992). Dimensions of knowledge sharing and reuse.	246
Computers and Biomedical Research, 25, 435-467.	247
Ohler, J. (2008) The Semantic web in education. Educause Q, 31(4).	248
http://net.educause.edu/ir/library/pdf/EQM0840.pdf.	249
Time T Devis H Millard D Meel M Milite C and Mills C	250

Tiropanis, T., Davis, H., Millard, D., Weal, M., White, S. and Wills, G. 250 Aut (2009). Semantic technologies in learning and teaching (SemTech) - 251 JISC Report. 252

Author Query Form

Encyclopedia of the Sciences of Learning Chapter No: 1096

Query Refs.	Details Required	Author's response	
AU1	Please provide missing details for the reference "Tiropanis et al. (2009)".	Publisher: Joint Information Systems Comn	nittee (JISC),

URL: http://www.jisc.ac.uk/media/documents/projects/semtechreport.pdf.

Also: proposing the use of quotes in page 1, column 2, line 62 as indicated in