

Sharing Digital Resources in Teacher Education: an Ontology-based Approach

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Abstract. Teacher Education (TE) is a dynamic, lifelong process that needs to fully embrace innovation and assume a broader European perspective. The EC-funded Share.TEC project aims to provide enhanced, culturally-aware access to TE-related resources across Europe by means of a federated resource brokerage system whose semantic core is the proposed Teacher Education Ontology (TEO). This paper describes the rationale for an ontology-driven approach, gives an overview of TEO's multi-layered structure for addressing multicultural and multilingual issues, and presents some aspects of the TEO implementation that allow for language-independent conceptualization and multidimensional hierarchical searching and filtering. Other TEO features are also discussed, including the support for dynamically generated user interface and system stability against ontology modifications.

Keywords: teacher education, ontology, ontology-based Information System, multicultural semantics

Introduction

In spite of its central role to sustain learning, the field of Teacher Education (TE) is generally slow both to embrace innovation and to generate it. TE practice is usually geared to meet the specific requirements of national systems that are linguistically and culturally bound; TE communities (even virtual ones) tend to focus on the immediate locus; TE practitioners resist to embrace digital culture, with only patchy adoption of ICT and scarce sharing of digital resources.

The goal of the EC-supported Share.TEC¹ project is to push innovation into initial and in-service TE. Share.TEC has undertaken to build an advanced user-focused system dedicated specifically to fostering a stronger digital culture in the TE field by: aggregating metadata for TE-related digital resources located Europe-wide; providing personalized, culturally-sensitive brokerage for the retrieval of relevant digital content; supporting the development of a Europe-wide perspective among those working in and with the TE community.

The semantic core at the heart of the proposed Share.TEC system is a Teacher Education Ontology (TEO), which has been developed by partners in the Share.TEC project in collaboration with international experts. The scope of this ontology has been set on concepts relevant to the domain of Teacher Education,

¹ Share.TEC - SHAring Digital REsources in the Teaching Education Community, eContentplus programme (ECP 2007 EDU 427015); <http://www.sharetecproject.eu/>.

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with particular regard for aspects considered pertinent to the sharing of digital resources and practice among potential members of the Share.TEC community, namely teacher educators, teachers, academic/educational publishers and content developers.

The purpose of TEO within the Share.TEC system is to provide:

- pedagogical characterization of digital content;
- representation of user profiles and competencies;
- a basis for multilingual and multicultural functionality;
- support for personalized interaction with adaptive user applications;
- support for the implementation of recommending functions.

There are a number of reasons why an ontology-based approach has been adopted for the Share.TEC system and platform. The chief among these is to permit the sharing of concepts among people. Share.TEC's European perspective necessarily means that its users will bring to the community different languages and cultures. What's more, the TE field includes people with very different backgrounds, ideas and assumptions. In such a situation, effective communication and shared understanding can be difficult to achieve. Accordingly, TEO seeks to reduce conceptual and terminological confusion by identifying and properly defining a set of concepts (and their relations) relevant to TE in Europe. The result should be a non-ambiguous and consistent vocabulary for identifying those concepts, and a framework on which culturally and linguistically diverse versions of that vocabulary can be mapped.

TEO also supports adaptive user interfaces and services that use reasoning techniques. This allows for the implementation of inferential search engines, advanced ranking solutions and flexible representation of user profiles. Importantly, TEO has also provided the basis for the definition of a common metadata model for describing TE-relevant digital resources.

1 A Domain Ontology of Teacher Education

1.1 TEO Definition and Development

Domain ontologies, upon which Information Systems are subsequently based, can be considered as repositories of knowledge that allow accumulation and systematization of knowledge. According to Allard et al. [1], "*Domain ontologies should also be conceived as use-neutral, in the sense that they are meant to serve as a foundation. Building on this foundation, different problems can be tackled, various applications derived, knowledge bases built. Consequently, domain ontologies should be relatively stable and aim to be a long-lasting conceptual structure*".

As previously mentioned, the present work on domain ontology for Teacher Education seeks to capture those concepts of the TE world that are relevant for sharing digital resources among practitioners. It is also to provide a framework for mapping multicultural and multilinguistic semantics.

TEO is grounded in existing research, especially that of Mizoguchi *et al.* [1], [2] and Guarino [3]. Specifically, it draws on three main models of reference: the OMNIBUS ontology³, whose domain is education; the LORNET competency

³ <http://edont.quee.jp/omnibus/doku.php>.

modelling ontology⁴; and the POEM (Pedagogy Oriented Educational Metadata) model [4]. Other relevant sources that have influenced TEO's design include DOLCE⁵, ONTOURAL [5], ALOCOM⁶, PROTON⁷ and user modeling ontologies [6], [7].

1.2 Basic Concepts of TEO

In its current version, TEO defines 162 classes and 78 properties. Figure 1 presents the main concepts identified.

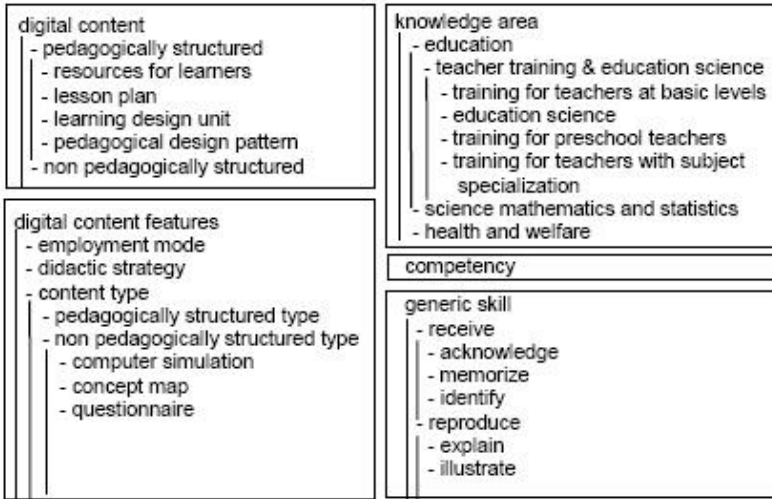


Fig. 1. Overview of TEO's main concepts.

Digital content refers to educational resources and artifacts closely related to the concept of the “learning object” [8]. Depending on its nature, a *digital content* artifact can be categorized as (i.e. “is-a”) *pedagogically structured* or *non-pedagogically structured type*. *Resources for learners*, *lesson plans*, *learning design units* and *pedagogical design patterns* belong to the *pedagogically structured* category.

The *digital content* concept is also defined by other characteristics including *employment mode*, *didactic strategy* and *content type*. These act as *digital content features*, i.e. they are related to *digital content* instances via a *part of* relationship. A *computer simulation*, a *concept map* and a *questionnaire* are all examples of *non-pedagogically structured content type*.

Knowledge areas consist of topics drawn from the EUROSTAT [9] taxonomy of education and training. This classification was adopted as a reference due to its European perspective and pertinence to the TE domain⁸. The knowledge area hierarchy allows digital content to be described in terms of discipline and permits specification of the user's areas of interest. Association of a knowledge area and a *generic skill* generates a *competency* concept, according to Paquette's

⁴ <http://www.lornet.org>

⁵ <http://www.loa-cnr.it/DOLCE.html>

⁶ <http://ariadne.cs.kuleuven.be/alocom/>

⁷ <http://proton.semanticweb.org/>

⁸ For interoperability purposes EUROSTAT has been mapped against Dewey's Decimal Classification: <http://www.oclc.org/dewey/>.

approach to competency modeling [10]. In TEO, competencies are related with the *digital content* concept: this allows resources to be described and classified according to the specific competencies they address.

Finally, we considered the *role* concept, which draws on Mizoguchi’s model [2]. Once basic concepts were defined in TEO, a knowledge validation process was carried out by TE actors & experts to progressively improve TEO’s conceptual framework and its technical implementation. Some important requirements emerged from development of Share.Tec’s technical integration study and system architecture specification, so a new release of TEO has been produced to fulfill these needs.

2 TEO Implementation

TEO is designed to represent concepts and build relations between entities defining the domain of Teacher Education. This in itself is a positive step towards defining a consistent and complete picture of this domain, but TEO also contains important information that can be used by the Share.TEC software application.

The main contents of the Share.TEC repository are data harvested from external repositories or provided by community members. Along with these primary data, the main repository contains an online dynamic representation of TEO that supports core system services and features like: (a) language-neutral concept-oriented data; (b) hierarchal searching and filtering; (c) dynamic multilingual user interface.

2.1 Internal Logical Structure of TEO Representation

The internal structure of a TEO entity is designed with a minimalistic approach in mind – the simplest structure that facilitates all required functionality. Each TEO entity is represented as an individual node that is interconnected with other nodes through relations and that contains a list of translations of the concept represented.

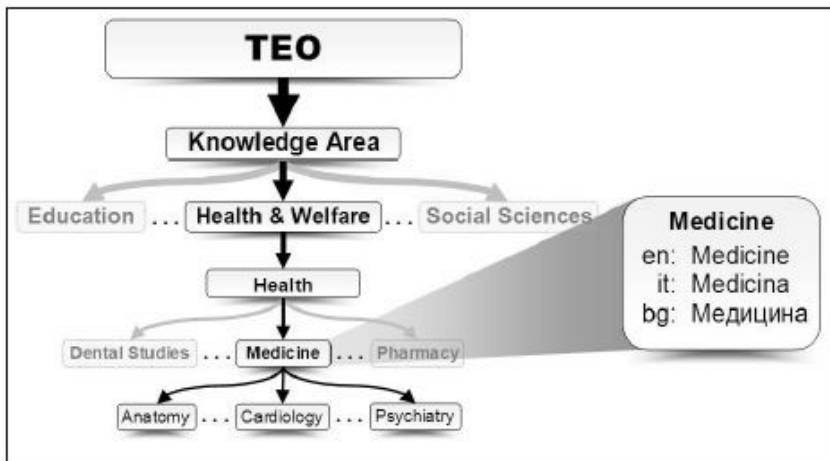


Fig. 2. A vertical slice of TEO representing the full path down to Cardiology.

The internal physical structure is more complex and is not discussed in this paper. It defines a wider spectrum of relations between ontology entities and contains additional data in order to allow (a) complete reconstruction of the ontology into a valid OWL file; and (b) support for extended functionalities like reasoning. While the logical representation does not distinguish between classes, subclasses and instances, the distinction is made in the physical representation.

TEO hierarchies are constructed by defining parent-child relationships between various nodes. This consolidates all TEO nodes into a single tree-like data structure that represents the domain knowledge of Teacher Education. Additional cross-branch relations are also represented, but these are not discussed here. Figure 2 shows a vertical slice describing the complete path from the top concept, TEO, down to Cardiology. The path goes through Knowledge Area node, which is the root of the Knowledge Area hierarchy within TEO.

2.2 Multilingual Support

Every node contains a set of translations of the node's concept into system-supported languages. This information is used when processing multilingual data from repositories across Europe. Whenever incoming data contains a concept expressed in a native language, Share.TEC scans TEO to find the corresponding node. When such data are processed, their texts are replaced by references to conceptual nodes. This makes the internal representation of data language-independent and links various translations of the same concept – Figure 3. The same approach is used to translate concepts into users' native languages. The original data harvested from, say, an Irish repository, may contain the word "Medicine" but the same data viewed by Italian or Bulgarian users will be displayed as "Medicina" or "Медицина".

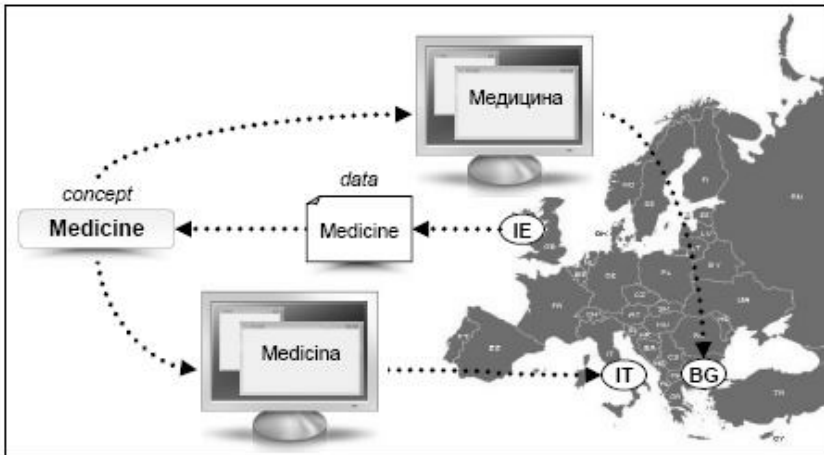


Fig. 3. Native languages and language-neutral conceptualization.

Translations are actually used not only for importing and displaying data, but also for searching and filtering. A Bulgarian user may define a search criterion in Bulgarian, the system will match it to the corresponding concept node and will find all data referring to that concept node, irrespective of language.

2.3 Multidimensional Hierarchal Data Space

TEO hierarchies can be represented as axes in a multidimensional data space. These axes are not mathematically continuous but are discrete sequences of concepts. *Figure 4 – Case A* shows an example of a 3D data space defined by three hierarchies. Solid circles represent selected entities. Data elements inside the box are the user's search or filtering results. The multidimensional interpretation of Share.TEC data enriches the way users perceive TEO. They can "slide" along TEO axis by axis, slicing the data space in their preferred way. Users are free to select any number of TEO axes and in any order.

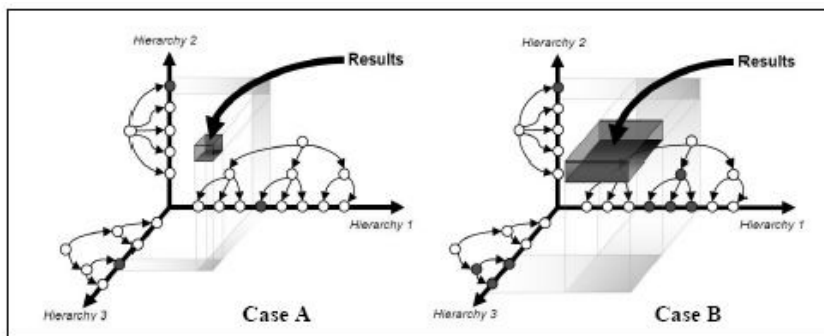


Fig. 4. A generic multidimensional data searching (Case A) and Share.TEC hierarchal searching of data bound by a virtual searching box (Case B).

TEO has already captured and classified relationships between concepts. This information is used to define the boundaries of each group of related entities at any level of classification. Groups of related entities can be retrieved simply by accessing an upper-level node from the corresponding hierarchy (see *Figure 4 – Case B*). For example, if the parent of Medicine (i.e. Health) is selected, then all medicines, dental studies, medical diagnostics, treatment technologies, nursing, caring, pharmacy, therapy and rehabilitations are selected.

The effect of this multidimensional and hierarchal approach is that the user can broaden or narrow the filtering criteria in a natural and domain-aware way. Axes corresponding to parameters which are not of interest to the user are totally ignored.

The multidimensional approach does not only utilize the taxonomies in TEO. A class together with its properties and the properties thereof (and so on) can also be treated as a hierarchy and thus be subject to multidimensional search and navigation.

3 Future Work

This paper has presented a domain-ontology for Teacher Education (TEO). Some of the major ideas underpinning the adopted approach were discussed, as were technical aspects regarding the implementation of TEO and related services. Although minimalistic, the proposed implementation of TEO covers a wide range of features required for appropriate functioning of Share.TEC portal. It has been found that this implementation approach might be suitable

for representing multicultural diversity in TEO. This is especially important where two or more cultures have their own specific views of TEO which are not compatible.

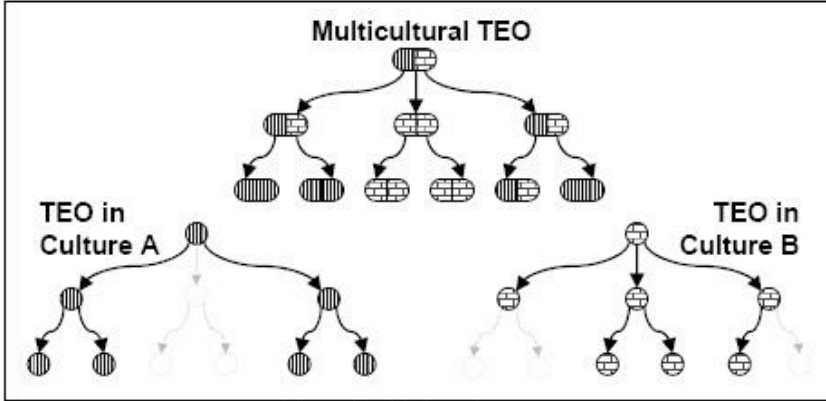


Fig. 5. Multicultural coverage.

Multicultural support goes beyond multilingual support, as it deals with those elements for which translation is problematic. The basic assumption is that when a node contains a translation in a given language, then the corresponding concept exists in the culture based on that language. Thus the same data space will be seen in different ways by different users – Figure 5. Although the projection of TEO onto a given culture may hide some of the concepts (especially those which do not exist in that culture), users are still able to view and work with the complete data space if they remove the language/culture filter. However, in this case they risk encountering unfamiliar and untranslatable concepts.

TEO	Culture S		n/a	Primary	Secondary	Pr	Tertiary	Translations in language S
	n/a	Primus	Primus	Secundus	Pre-Tertius	Tertius	Level of cultural independent conceptualization	
	C0	C1	C2	C3	C4	C5		
	Pre-Primo	Pre-Primo	Primo	Secundo	Tertio	Tertio	Translations in language O	
	Culture O		Pre-Pr	Primary	Secondary	Tertiary		

Fig. 6. Mapping cultural-dependent concepts.

Figure 6 demonstrates one possible implementation of mapping multicultural aspects that do not completely match. Shown are two cultures S and O and an imaginary educational level classification. Culture S uses language S and defines these concepts: *Primus*, *Secundus*, *Pre-tertius* and *Tertius*. Culture O uses language O and defines similar concepts: *Pre-primo*, *Primo*, *Secundo* and *Tertio*. The middle layer represents the cultural independent conceptualization, implemented as TEO nodes.

The concept of secondary education is the same in both cultures and has exact mapping – they both map onto concept *C2*. However, primary education is more interesting, because in culture *S* it maps to concepts *C1* and *C2* (which are both called *Primus*), while in culture *O* it maps to only *C2* (called *Primo*). If a search is done using the word *Primus*, then the system will map it to both *C1* and *C2* and will return all data that reference them. This includes all *Primus*, all *Primo* and all *Pre-primo*. If the search is for *Primo*, then the results will contain only *Primo* and *Primus*.

The study of all possible combinations for concept mapping reveals that this approach provides an adequate multicultural coverage. In the worst case it may return some extra results, which were not requested, but are considered by TEO as highly related to the search. The approach behaves well for concepts which do not exist in all cultures by providing results which are conceptually close.

Acknowledgements. All the authors contributed on an equal basis to the conceptual design of this paper. ITD authors were mainly responsible for the introduction and first section, while Pavel Boytchev of NIS-SU was mainly responsible for the second and third sections.

References

1. D. Allard, J. Bourdeau, R. Mizoguchi, Towards modeling knowledge of cultural differences and crosslinguistic influence in Computer-Assisted Language Learning (CALL). In: E. Blanchard & D. Allard, Proceedings of the Culturally Aware Tutoring Systems (CATS) Workshop, ITS Conference 2008, Montreal, Canada, June (2008), 11-22. Last retrieved from <http://www.iro.umontreal.ca/~blanchae/CATS2008/CATS2008.pdf> April 10, 2009.
2. R. Mizoguchi, E. Sunagawa, K. Kozaki, & Y. Kitamura, A model of roles within an ontology development tool: HOZO. *Journal of Applied Ontology* 2(2) (2007), 159-179.
3. N. Guarino, C. Masolo, A. Oltramari, L. Schneider, Sweetening Ontologies with DOLCE. In Proceedings of the 13th International Conference on Knowledge Engineering and Knowledge Management (EKAW02), Lecture Notes in Computer Science 473, (2002).
4. S. Alvino, P. Forcheri, M.G. Ierardi, & L. Sarti, A general and flexible model for the pedagogical description of learning objects, Proceedings of WCC2008, Milano, Italy, September (2008).
5. M. Grandbastien, F. Azouaou, C. Desmoulins, R. Faerber, D. Lecllet, & C. Quénu-Joiron, Sharing an ontology in education: lessons learnt from the OURL project, Proceedings of Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007), Niigata, Japan, July (2007). Last retrieved from <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=04281129> on April 10, 2009.
6. D. Paneva, Ontology-based student modeling, Proceedings of the Fourth CHIRON Open Workshop Ubiquitous Learning Challenges: Design, Experiments and Context Aware Ubiquitous Learning, Turin, Italy, September (2006), 17-25.
7. L. Razmerita, A. Angehrn, T. Nabeth, On the role of Actor models and Actor modelling in Knowledge Management Systems, in Proceedings of HCI International Conference, Greece (2003).
8. D.A. Wiley, Connecting learning objects to instructional design theory: a definition, a metaphor, and a taxonomy. In: D.A. Wiley (ed.), *The Instructional Use of Learning Objects*, Association for Instructional Technology, (2000). Last retrieved from <http://reusability.org/read/chapters/wiley.doc> on April 10, 2009.
9. R. Andersson, A.K.Olsson, *Fields of Education and Training*, EUROSTAT (1999).
10. G. Paquette, An Ontology and a Software Framework for Competency Modeling and Management, *Educational Technology & Society* 10(3) (2007), 1-21.