Developing an Ontology for Curriculum & Syllabus

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Abstract. Semantic Web and ontology engineering can play significant role in the area of education. In this paper we focus on the conceptualization of educational knowledge structures in an academic setting. More specifically, we present the methodology and the development process of an educational ontology. that can be reused and applied to any type of course in different institutions and contribute to several curriculum tasks and course activities.

1 Introduction

The application of semantic web and ontological technology in education offer powerful benefits and will change the current education mode. Previous research [1], [2], [3] has already identified the importance of developing rich ontologies in the field, however, yet no current ontology conceptualizes educational entities within curriculum and syllabus with sufficiency and richness in order to support rich services on top is available. Curriculum management and development can be improved using ontologies in curriculum tasks like aligning, comparing, and matching between universities, educational systems or relevant disciplines. Having an ontology available, syllabus items can be effectively described and annotated enabling intelligent systems to support teaching and learning by offering automated services like syllabus semantic searching, matching and interlinking [6],[7], syllabus recommendation and evolution [], etc.

The purpose of this work is the identification and conceptualization of the entities and procedures within an academic institution, aiming to model the core concepts of a higher education curriculum (Curriculum, Course, and Syllabus). The developed ontology aims to be highly transferable and reusable to other schools and universities.

2 Ontology Development

The design and the development of an ontology usually encompasses several tasks. In our approach we combined two widely used methodologies [8], [9] resulting in four main phases: (1) Domain and Purpose definition, (2) Ontology building, (3) Evaluation, (4) Documentation. Bellow we provide more details for each phase.

(1) Domain and Purpose definition. The purpose of this work is the identification of concepts and entities that play important role in a third-level curriculum, aiming to provide a semantic model for the main teaching and learning concepts within an academic environment. The developed ontology conceptualizes academic knowledge structures such as curriculum, course, syllabus, event, topic, etc. The definition of competency questions outlines the expectations that the designed ontology should fulfill - used in the evaluation process as well. Example competent questions include: (i) Which are the core Courses in a study program? (ii)Which degrees does a Person have? etc (see [4] for the complete list).

(2) Ontology building. Building a domain ontology requires deep understanding of the domain of interest. The necessary knowledge was acquired from domain experts, textbooks and existing ontologies. In addition to the educational ontologies found in the literature, search engines (*Google*, *Swoogle*, *OntoSearch*, *SemSearch*) and ontology repositories (DAML Ontology Library, *Ontolingua*, *SHOE*) were used to identify relevant ontologies. We identified five partly relevant ontologies. *Bowlogna* ontology [2] focuses mainly on study tracking and student mobility, and *BBC Curriculum* describes curricula in a broader view (www.bbc.co.uk/ontologies/curriculum). AIISO (vocab.org/aiiso/schema) has a different focus, targeting the structure of an organization while University Ontology (www.cs.umd.edu/projects/plus/SHOE/onts/univ1.0.html) does not include essential concepts (e.g. Syllabus, Event). A closely related ontology is also available only through a relevant paper [1]. Compared to these approaches, our ontology is more extensive and rich, modeling important concepts in Curriculum and Syllabus, supporting rich services on top. **Enumerate important terms**. In this phase, we made a complete list of all possible terms we would like either to describe or to make statements about. We inspected carefully existing related ontologies and analyzed a variety of textual syllabuses whereas templates and curriculum guides were also considered (such as www.adip.gr/en/accreditation-docs.php). The result was a comprehensive list of the important terms of the domain, shown in *Table 1*. **Define classes and class hierarchy**. We followed a top-down development process to organize concepts, starting from the “Whole” to the “Part”. The most important terms are considered to be the top-level classes in our ontology with the remainder to be sub-classes or standalone classes. Finally, we ended up with 41 classes, as shown in *Fig. 1*. It must be noted, that some classes, i.e. *AdministrativeStaff*, *TechnicalStaff*, *Lecturer* and *Researcher*, are included mainly for classification reasons as well as for future use and extension of the ontology. In addition, ontology mappings have been established with relevant terms in other interconnected ontologies and vocabularies (such as Schema.Org and Dublin Core), in order to enable alignment and easier discovery by other organizations and search engines. **Describe the properties of classes**. In this step, we defined 54 *object properties* that describe relationships between individuals (instances of classes), 42 of which are participating in 21 pairs of inverse object properties. We also defined 76 *data properties* in order to attach rich information about individuals. Considering the class inheritance, each property is attached to the most general class. **Attaching facets to Properties**. Each *data property* has an appropriate value type, cardinality, and allowed values. For each object property we set the allowed values which are instances of other related classes, using the correposiding *domain* and the *range* definitions. It must be noted that, as a course might be taught by several instructors each year (corresponding to individual Syllabus) some properties related to Course (such as *instructorOf*, *supervisorOf*, *assistsInCourse*) have *Syllabus* as a range. **Create instances**. Finally, our ontology is enriched with a large number of individuals, since they are playing important role in evaluation process. We added a total of 549 individuals, most of them in classes that participate in the competency questions. Adding individuals allowed us also to test the completeness of the available domain terms and properties in modelling domain knwoledge.

Table 1: List of important terms within the subjects of Curriculum, Course and Syllabus

Curriculum	Syllabus
Curriculum	Syllabus
Educational Organization	Topic
Discipline	Learning Outcome
ProgramofStudy (Academic Degree)	Teaching Method
Person	Instructor (Professor)
Course	Student
Publication	Event

(3) Ontology evaluation. We followed an internal technical evaluation approach. After the end of each phase, the author and relevant domain experts evaluated the available definitions. Special attention has been paid to the consistency, completeness and conciseness of the ontology. The final technical evaluation included, except manual examination and a software tool (oops.linkeddata.es/) that offers automate test against the most common errors and pitfalls in ontology development. Finally, the set of competency questions had been enriched, resulting in 27 questions in total. Those questions when then used to evaluate the ontology in corresponding usage scenarios with SPARQL queries.

(4) Ontology documentation. Considering that effective knowledge sharing and reuse, requires adequate documentation, we have provided internal and external documentation with various pieces of information. Internal documentation includes information annotated in ontology elements as metadata, written in two languages (English and Greek) giving to ontology bilingual character. External documentation includes an extended document that describes in details step-by-step the whole ontology development process, including, among others, purpose, class definitions, description of class properties, and evaluation.

Overview of the ontology. Our ontology comprises of 41 concepts in a taxonomy, 9 of which are the top-level concepts of the ontology, namely the *FieldofStudy*, *EducationalOrganization*, *Person*, *ProgramofStudy*, *Course*, *Syllabus*, *Event*, *Topic* and *Resource* (*Fig. 1*). It also includes 54 objects properties for establishing relations between concepts and 76 data properties for describing concepts characteristics in detail. All entities are enriched with additional annotation information. The generated ontology is also available online (http://xworks.gr/ontologies).

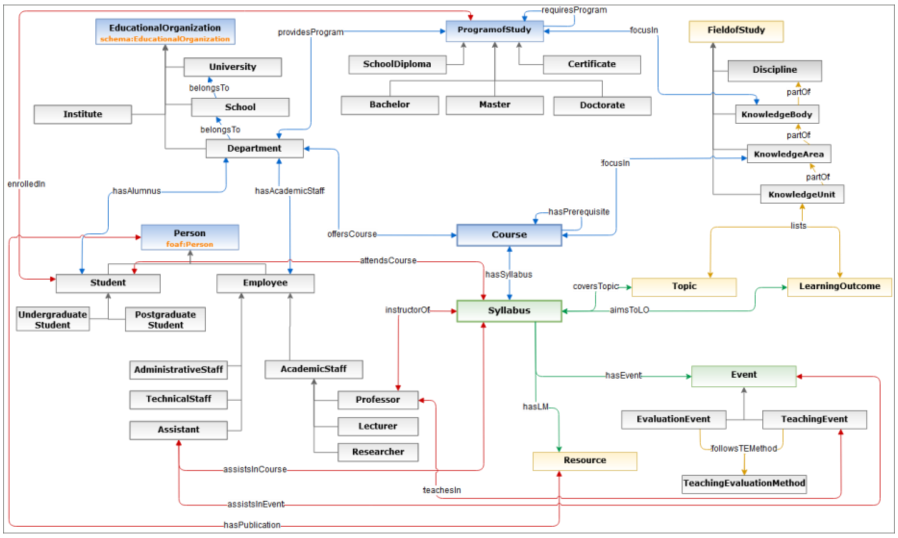

Fig. 1. Classes, class hierarchy and their relations of CCSO

3 Conclusion

In education, curriculum and syllabus offer important information to instructors and students. This paper presents an educational ontology for the semantic modeling of curriculum and syllabus in higher education with the methodology and development process briefly analyzed. The developed ontology has the potential to be reused and sharable among institutions and to contribute to information sharing and reuse.

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