Abstract—Learning opportunities play an important role in the vision of curriculum favored by the Bologna Process. This paper proposes an ontology intended for representing learning opportunities. The ontology is designed in accordance with European standardized models addressing metadata sufficient for representing learning opportunities. Since the models are proposed as Dublin Core application profiles, the ontology has been implemented following a set of guidelines for expressing Dublin Core application profiles using OWL. Proposed ontology facilitates the introduction of Semantic Web technologies in the field of curriculum management, and will be a start-point for the implementation of a Semantic Web application aimed at curriculum management.

I. INTRODUCTION

A. Learning opportunities

The Bologna Process brings a curriculum restructuring to the European higher education that challenges traditional – meaning vocational and disciplinary – curriculum discourses by placing emphases on flexibility and mobility within the European Higher Education Area, and, more generally, employability in the European market. The credit accumulation and transfer system, supported in the Bologna Process, favors the image of students as “active partners in horizontal pedagogical relations where the students’ own choices and interests play a major role” [1]. The significance of learning opportunities in such a contemporary educational setting is well defined by William Pinar in [2], where he states:

“What the conjunctive relationship ... between curriculum and pedagogy invites, then, is an inflation of the claims and liabilities of the teacher that deludes both parents and politicians (not to mention students and teachers) that the locus of responsibility – the very site of education – is the teacher, not the student. The truth is, of course, quite different: teachers provide educational opportunities; students are responsible for taking advantage of them.” (emphasis added)

B. Metadata for Learning Opportunities - Advertising (MLO-AD)

Metadata for Learning Opportunities - Advertising, MLO-AD [3] is a metadata model sufficient for the representation and advertisement of learning opportunities. The model has been adopted by Learning Technologies Workshop with European Committee for Standardization as a European standard. The standard is a lightweight model that easily fits into the existing business processes as well as with technologies currently in use.

The main purpose of the model is to enable students in the European Higher Education Area to make informed decisions concerning learning opportunities and, if needed, direct the students to other sources of information on learning opportunities. The standard is based upon the following basic concepts:

- Learning Opportunity – an organized possibility for an individual or a group to advance their educational status. It can be a part of informal as well as formal education process.
- Learning Opportunity Provider – an agent, for example an institution or a person, that provides a learning opportunity.
- Learning Opportunity Specification – an abstract description of a learning opportunity including relevant data common to all the implementations of the learning opportunity. This concept implies a possibility that there can be multiple instances of one and the same learning opportunity.
- Learning Opportunity Instance – data relevant to the concrete implementation of a learning opportunity.

In accordance with the basic concepts, the model proposes three classes of resources:

- Learning Opportunity Provider
- Learning Opportunity Specification
- Learning Opportunity Instance

The classes are all the subclasses of the same class, which is Learning Opportunity Object.

Some of the elements, namely Contributor, Date, Description, Identifier, Subject, Title and Type defined in MLO-AD are taken directly from the Dublin Core Metadata Element Set. Others are introduced as new elements.

C. ECTS Information Package/Course Catalogue MLO application profile

The Bologna Process [4] strives to establish comparability and compatibility in the European Higher Education Area. The European credit transfer and accumulation system [5] is a system intended for the representation of credits in the European Higher Education Area, and that system involves all the countries that take part in the Bologna Process. The European Committee for Standardization has defined an extension of MLO-AD model named ECTS Information Package/Course Catalogue MLO application profile, MLO ECTS IP/CC, adopted as a standard for representing data relevant in the context of credit transfer and accumulation in the European Higher Education Area [6].
In the MLO ECTS IP/CC there is a strict separation between course units and degree programmes. Therefore, two types of Learning Opportunity Specifications have been identified: Degree Programme Specifications and Course Unit Specifications. There are two types of Learning Opportunity Instances as well, namely Degree Programme Instance and Course Unit Instance.

The MLO ECTS IP/CC introduces a number of elements. The scope of this paper does not permit us to analyze the elements one by one. Let us just mention that all the elements are introduced as subelements of the elements defined in the MLO-AD application profile.

D. Motivation

The authors of this paper believe that the ultimate purpose of the metadata for learning opportunities is to enable high level of the semantic interoperability in the European Higher Education Area through the technical mapping of the data on the existing educational practices (e.g. data on courses, degree programmes, etc.) onto the interoperable specification of learning opportunities.

There are numerous possible applications of the metadata for learning opportunities [3]. Some of them are:

1. Formal course advertisement, which would:
   - Facilitate the introduction of new information and communication technologies, such as Web 2.0 or Semantic Web, into the education process, since the information on learning opportunities would be formally represented,
   - Enhance the students mobility since the data relevant in the credit transfer would be directly accessible,
   - Reduce the operation costs in the educational institutions, since some of the common tasks (such as the preparation of accreditation documents and the recognition of foreign diplomas) would be automated to some extent,
   - Increase consistency of the information on learning opportunities in different educational institutions,
   - Simplify and improve the aggregation of the information on learning opportunities, and
   - Enable the introduction of additional information on learning opportunities without increasing the complexity of the model.

2. Mediated registration to learning opportunities, for example by using broker services, which would enhance the accessibility to the learning opportunities.

3. Comparison of learning opportunities amongst each other as well as with the reference benchmarks.

4. Learning opportunities evaluation and quality assurance that would:
   - Support the application of proactive quality evaluation and surveillance in the education process,
   - Foster the Bologna Process acceptance at the institutional, national and international level,
   - Support the specification of educational requirements at the national and international level, and
   - Be a foundation for monitoring the learning opportunities, including lifelong learning.

5. Tracking the students’ achievement through the transcript of records, which would enable:
   - Digitizing students’ grades,
   - Monitoring the completeness of individual students’ achievement in the particular fields,
   - Direct transfer of records to the host educational intuition,
   - Inclusion of data on the educational opportunities taken by students – possibly at foreign host institutions – into a student management system, and
   - The authentication of transferred records.

Due to these potential applications, the following groups of stakeholders that would benefit from the usage of the models can be identified:

- The institutions that offer educational opportunities, and, therefore, are interested in advertising the opportunities,
- The institutions that offer electronic services for learning opportunities aggregation and search, and
- The individuals and institutions in charge of the comparison of educational opportunities (e.g. government institutions, employers, etc.).

Considering the wide application of the standards (MLO-AD and MLO ECTS IP/CC) and the requirement that the standardized models must be lightweight and easy to use, the models are defined as Dublin Core application profiles. A Dublin Core application profile is a set of documents that specify and describe Dublin Core application profiles. A Dublin Core application profile is a set of documents that specify and describe Dublin Core application profiles. A Dublin Core application profile is a set of documents that specify and describe Dublin Core application profiles. A Dublin Core application profile is a set of documents that specify and describe Dublin Core application profiles. A Dublin Core application profile is a set of documents that specify and describe Dublin Core application profiles. A Dublin Core application profile is a set of documents that specify and describe Dublin Core application profiles. A Dublin Core application profile is a set of documents that specify and describe Dublin Core application profiles.

The standards include two implementations of the models in machine readable syntaxes: the XML Schema and the RDF Schema [3]. There is also one illustrative XML binding for MLO-AD proposed in [8]. The thesis [9] proposes the usage of Java Data Object approach to representing (and persisting) the metadata from MLO-AD.

As far as the authors of this paper are informed, currently there are no OWL (Web Ontology Language) implementations of the models. Representing the models as OWL ontologies would be useful for two reasons. Firstly, it would simplify the integration of the systems for advertising learning opportunities. Secondly, it would enable reasoning over the represented learning opportunities, and therefore, facilitate discovering the knowledge implicitly included in the learning opportunities metadata. In addition, an OWL ontology is particularly convenient machine readable format for a Dublin Core application profile because of its ability to represent semantically rich models containing property usages – the ability that is not directly accessible in either RDF Schema or XML Schema. For these reasons this paper proposes OWL ontologies created in accordance with the models.

Even though the standards do not include the OWL versions of the models, the standards foresee the possibility of ones. In addition, the standards state that the OWL implementation of the models would enable dynamic supertype substitution [3].
II. EXPRESSING THE APPLICATION PROFILES IN OWL

There is a wide range of formats suitable for implementing a Dublin Core application profile, varying from natural languages and tabular representations to RDF and XML Schemas. The choice of a right format depends on the level of formality and precision required from the model [10], and must take in consideration the overall purpose of the model. Often, one and the same model is represented in different formats.

The general rules for choosing a machine readable representation for a Dublin Core application profile are given in the European Committee for Standardization’s document [11] which considers XML Schemas, RDF Schemas and OWL ontologies as possible representations.

Because the authors have chosen OWL for representing the models, the guidelines [11] were appropriated as follows:

- **Strict separation of datatype and object properties** – All the properties defined in MLO-AD and MLO ECTS IP/CC application profiles, except the ones directly taken from the Dublin Core Metadata Element Set, are already defined as either object or datatype properties in the standards. The properties from the Dublin Core Metadata Element Set are identified as object or datatype properties depending on their subproperties. It turns out that there were no collisions, meaning that there were no situations in which some subproperties of one and the same property taken from the Dublin Core Metadata Element Set would be datatype properties, while some would be object properties.

- **Poor property exchange among OWL ontologies** – This aspect is not considered in the paper for the reason that the community gathered around higher education curriculum is coherent. Other communities close to this research, such as e-Learning and e-Government communities, will be introduced to the advantages of the models.

- **The different nature of basic concepts in Dublin Core application profiles and ontologies** – In this paper the elements defined in the Dublin Core application profiles are interpreted as properties defined over the classes of resources in the ontologies.

- **The need for additional modeling when developing an ontology in accordance with a Dublin Core application profile** – When the ontologies were developed, some circumstances required additional modeling. For example, when properties taken directly from Dublin Core Metadata Element Set were introduced, they had to be identified as datatype or object properties, resulting with the more specific and semantically richer models than the Dublin Core application profiles. However, the authors tended to introduce as few new concepts into the ontologies as possible. For example, since the application profiles do not restrict the properties occurrences, no value constraints and no cardinality constraints were introduced to the classes in the ontologies.

- **The possibility of producing an inconsistent ontology** – The authors did not encounter a threat of introducing inconsistencies while developing the ontologies.

- **Insufficient semantic expressiveness of certain OWL dialects** – The ontologies are implemented in OWL Lite and no situation in which the dialect would be semantically insufficient did show up.

III. MLO ONTOLOGY

The MLO-AD application profile rests upon a set of elements that are a subset of the Dublin Core Metadata Element Set, necessary for representing learning opportunities. The MLO-AD application profile introduces a set of elements that enable the representation of general information on learning opportunities. The MLO ECTS IP/CC application profile extends this model by introducing the elements necessary for representing learning opportunities in the context of credit transfer and accumulation in the European Higher Education Area. Since these three logical units have been identified in the models, the following three ontologies have been implemented:

- The Dublin Core ontology, representing the subset of Dublin Core Metadata Element Set used in the models,
- The MLO-AD ontology that imports the Dublin Core ontology, and introduces new classes and properties, and
- The MLO ECTS IP/CC ontology that imports the MLO-AD ontology (and therefore, indirectly imports the Dublin Core ontology) and specializes some of the imported classes and properties.

Separation of the ontologies is of particular importance since it enables the same learning opportunities to be interpreted differently depending of the context in which they are being observed. Namely, each learning opportunity can be seen as a plain resource, if only the Dublin Core ontology is considered, through its general characteristics when it is observed through the MLO-AD ontology or as a basis for credit transfer when the data represented by the MLO ECTS IP/CC ontology are being considered.

The ontologies are publicly available at the http://informatika.ftn.uns.ac.rs/MilanSegedinac/MLOOntologies

A. The Dublin Core ontology

There are numerous OWL implementations of the Dublin Core Metadata Element Set (for example [12], [13], [14]). However, as the authors of this paper are informed, there is no standard and generally accepted OWL implementation of Dublin Core Metadata Element Set [13].

Since neither one of the existing Dublin Core Metadata Element Set ontologies proved to be adequate start-point for implementing the models, the authors proposed their own implementation, consisting only of the elements used in the models. This ontology introduces strict separation between the datatype and object properties so that the properties dc:Contributor, dc:Description, dc:Identifier and dc:Title are identified as object properties (Figure 1), while the properties dc:Title, dc:Language, dc:Subject and dc:Type are identified to be datatype properties (Figure 2).
It should be noted that this ontology does not introduce any classes.

B. The MLO-AD ontology

This ontology imports the Dublin Core ontology and introduces four classes: \(\text{mload:LearningOpportunityObject}\), \(\text{mload:LearningOpportunityInstance}\), \(\text{mload:LearningOpportunityProvider}\) and \(\text{mload:LearningOpportunitySpecification}\). The classes and the relationships among them are shown in Figure 3.

The ontology introduces a number of object properties, shown in Figure 4, as well as datatype properties represented in Figure 5, following the MLO-AD application profile.

The domains and ranges of the properties were introduced in accordance with the MLO-AD application profile. No value constraints and no cardinality constraints were introduced to the classes.

C. The MLO ECTS IP/CC ontology

The MLO ECTS IP/CC ontology imports MLO-AD ontology (and, therefore indirectly imports Dublin Core ontology) and introduces new concepts. In the ontology there is strict separation between the set of course units and the set degree programmes. Therefore, new classes, namely \(\text{mloects:CourseUnitSpecification}\) and \(\text{mloects:DegreeProgrammeSpecification}\) are introduced as subclasses of the class \(\text{mload:LearningOpportunitySpecification}\), and \(\text{mloects:DegreeProgrammeInstance}\) and \(\text{mloects:CourseUnitInstance}\) are introduced as subclasses of the class \(\text{mload:LearningOpportunityInstance}\), as shown in Figure 6.
All the properties introduced in this ontology are subproperties of the properties defined either in the Dublin Core or the MLO-AD ontology. An overview of the properties follows.

Property `dc:Description` is specialized into its subproperties so to enable the representation of the data relevant in the context of credit transfer. The subproperties are shown in Figure 7.

![Figure 7. The subproperties of the property `dc:Description` introduced in the MLO ECTS IP/CC ontology](image)

In the MLO ECTS IP/CC ontology, some groups of contributors are identified. Therefore there are subproperties of the property `dc:Contributor` as shown in the Figure 8.

![Figure 8. The subproperties of the property `dc:Contributor` introduced in the MLO ECTS IP/CC ontology](image)

The different types of titles, namely course unit title, degree programme title and institution name, are defined as well (Figure 9).

![Figure 9. The subproperties of the property `dc:Title` introduced in the MLO ECTS IP/CC ontology](image)

This ontology also identifies some of the types of assessment, as shown in Figure 10.

![Figure 10. The subproperties of the property `mload:hasAssessment` introduced in the MLO ECTS IP/CC ontology](image)

The property that models educational objectives is specialized into its subproperties, separating the competences form the learning outcomes, as shown in the Figure 11.

![Figure 11. The subproperties of the property `mload:hasObjective` introduced in the MLO ECTS IP/CC ontology](image)

A special kind of `dc:Idefined` has been introduced as well, the one that represents course unit code and is modeled by the property named `hasCourseUnitCode`.

The ontology also introduces some datatype properties that are subproperties of the datatype properties defined in the Dublin Core and the MLO-AD ontologies. So, the ontology introduces subproperties of the property `dc:Type` aimed at representing course type, educational institution type and the type of learning opportunity (Figure 12).

![Figure 12. The subproperties of the property `dc:Type` introduced in the MLO ECTS IP/CC ontology](image)

The datatype property `mload:Level` is further specialized into its subproperties for representing course level and the academic year in which the course is being held (Figure 13).

![Figure 13. The subproperties of the property `mload:level` introduced in the MLO ECTS IP/CC ontology](image)

The property `CourseUnitTermPattern`, subproperty of the property `mload:Engagement`, is introduced in order to represent if the course is held in semesters or trimesters.

The domains and ranges of the properties were defined in accordance with the MLO ECTS IP/CC application profile. No value constraints and no cardinality constraints were introduced to the classes, in order to keep the ontology as generally applicable as possible.
IV. CONCLUSION

The scope of application of Semantic Web technologies in the field of curriculum management has been identified in [15]. The need for a curriculum management system has been identified in [16]. Following the line of research from these papers, this paper proposes an OWL implementation of the standardized Dublin Core application profiles aimed at representing learning opportunities.

The ontologies proposed in this paper will be the basis for a curriculum management system that will be implemented as a Semantic Web application. The system will be used in the context of higher education and will enable two things. Firstly, it will enable the integration of local curriculum management systems currently in use. Since the ontologies are based upon the standards applied in the context of Bologna Process, all the institutions that take part in the Bologna Process will be able to use the system directly. Secondly, it will facilitate the discovery of knowledge implicitly contained in the metadata on learning opportunities.

In order to achieve these goals, further research will have to take following steps:

• Mapping the curriculum models currently in use in higher education onto the proposed ontologies,
• If needed, extending the standardized application profiles and the ontologies proposed in this paper so to enable representing learning opportunities metadata in the concrete educational settings, and
• The development of a Semantic Web application that would be a user-friendly interface for using the ontologies, while abstracting the Semantic Web implementation details from the end-users.

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