CHAPTER 3

METADATA AND ONTOLOGY IN E-LEARNING ENVIRONMENT

Objective: This chapter investigates the existing learning object metadata standards. It discusses the current issues and drawbacks with existing metadata of educational domain to cope with educational semantic web vision. It also presents brief overview on various purposes of using ontology in e-learning domain and presents the ontological approach for context modeling and as a resource description metadata.

3.1 Introduction

The major challenge in e-learning system is to find appropriate learning resources from the distributed content repositories according to the needs and interests of the learner. For this, the educational resources must be accompanied and identified with standardized and semantic-based educational metadata. The metadata elements in e-learning domain must provide some meaning about the learning content. But the current existing metadata standards do not provide fully educative support information and also they are not completely suitable enough to integrate semantic web technologies into e-learning domain.

In this chapter, we discuss the issues surrounding the existing Learning Object Metadata (LOM) standards and the need of ontological approach to enrich existing standards. Along with this we investigate the possible approaches to strengthen the metadata. There are many metadata standards developed by different organizations, but almost all of them are mainly
developed for learning resource management purposes. So they are not able to provide full-fledged support to the new generation of e-learning system, such as educational semantic web and intelligent e-learning system. For the recent development in semantic-web technology and the pedagogical requirements of e-learner there is a need to enrich the existing metadata standards so as to make them suitable for current requirements.

3.2 Metadata for E-learning System

Metadata can be thought of as “data about other data”. Metadata in e-learning domain commonly refers to the descriptive information about learning resources. A metadata record consists of a set of attributes or elements, necessary to describe the learning resource. The learning resources associated with metadata are meant to be reusable in different contexts and they can easily be searchable and manageable. It is important to note that the resources considered as learning objects should be described by external descriptions called metadata. The metadata descriptions about the learning objects must be (although the term metadata is not exclusive for learning objects) with the following characteristics:

- In a general sense, Metadata “says something” about the learning object.
- Metadata is physically external to the educational resources; they can be in a separate file or can be obtained from a different service.
- Metadata use a technical format for expressing structural information of educational resources and for their interchange.
- Usually most of the metadata standards are encoded in XML format.
- A series of descriptors, fields or standardized elements allow metadata to obtain a certain level of interoperability between different systems.
The concept of learning objects is the self-contained and reusable learning entity that offers a new conceptualization of the learning process. These learning objects must have an external structure of information called learning objects metadata to facilitate their identification, storage and retrieval. Several metadata standards for educational Learning Objects (LOs) have been proposed by various research organizations but most popular metadata standard in the educational domain is IEEE Learning Object Metadata.

The metadata standards are designed especially for describing the characteristics of educational resources. According to Al-Khalifa et al., (2006) an important feature of LOM is that it is simple to use and has an inherent extension capability. This extensibility allows for the easy incorporation of new elements and enables LOM to meet the specific needs of applications.

3.2.1 Metadata Standards: An Overview

Learning object metadata is a data model, usually encoded in XML, is used to describe a learning object and similar digital resources used to support e-learning. The purpose of learning object metadata is to support the reusability of learning objects, to aid discoverability and to facilitate their interoperability, usually in the context of online Learning Management Systems (LMS).

Several educational metadata schemata have been proposed over time in order to better characterize learning objects. A widely adopted metadata element set for this purpose is IEEE LOM (LOM-Draft), a standard which has been designed especially for the description of educational resources. IEEE LOM defines a hierarchy of elements that are grouped into nine categories and each category is comprised of sub-elements that have some basic characteristics in
common and appear either as a single element or as an aggregation of other elements. The LOM approach specifies the syntax and semantics of learning object metadata. The complete metadata scheme of educational domain that can be pedagogically categorized is shown in Figure 3.1.

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**Figure 3.1 Pedagogically categorized metadata of educational domain**

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3.2.2 The Well-known Metadata Standards

The well-known metadata schemata designed to serve similar needs like IEEE LOM in the field of education are:

- Instructional Management Systems (usually referred to as IMS Global Learning Consortium or IMS GLC) (IMS Global\textsuperscript{19})
- Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE\textsuperscript{20})
- DuraSpace (DSpace\textsuperscript{21})
- Sharable Content Object Reference Model (SCORM\textsuperscript{22})
- Canadian Core Learning Resource Metadata Application Profile (CanCore\textsuperscript{23})
- Dublin Core Metadata Initiative (DCMI\textsuperscript{24})

The important characteristics of well-known metadata schemata are as mentioned below:

IEEE - LOM

- Learning Technologies Standard Committee (LTSC) and its draft standard is called Learning Object Metadata and it defines 80 fields within 9 categories as follows: 1-General, 2-Lifecycle, 3-Meta-Metadata, 4-Technical, 5-Educational, 6-Rights, 7-Relation, 8-Annotation and 9-Classification.

\textsuperscript{19}IMS Global: http://www.imsglobal.org/
\textsuperscript{20}ARIADNE: http://www.ariadne-eu.org/
\textsuperscript{21}DSpace: http://www.dspace.org/
\textsuperscript{22}SCORM: http://www.adlnet.gov/scorm
\textsuperscript{23}CanCore: http://www.cancore.ca/indexen.html
\textsuperscript{24}DCMI: http://dublincore.org/
Sample fields of IEEE-LOM include:

- Title: the name given to the resource.
- Language: the language of the intended user of the resource.
- Description: a textual description of the content of the resource.

IMS

- A further work on IEEE LOM
- Elements can be mapped to DC

ARIADNE

- A set of 47 elements of which 27 can be directly mapped to LOM elements
- Organized in six categories: General, Semantics, Pedagogical, Technical, Indexation, Annotation
- Fully compatible with IEEE LOM

Dublin Core (DC)

- A set of 15 core elements that can be further refined using attributes
- A general metadata standard suitable for describing digital objects of any kind
- DC-Terms constitute the most up-to-date formal version of the metadata terms and properties that roughly correspond to the whole set of DC elements and their qualifications
- Dublin Core Metadata Initiative (DCMI) Education12 consists of 23 elements that resulted from adding the 15 base DC elements to the extended 8 educational specific elements
3.2.3 Educational Metadata Application Profiles

As more and more applications are implemented using educational metadata, it becomes obvious that it would be difficult for a single metadata model to accommodate the functional requirements of all applications. This has created the need for what are known as application profiles.

Among the well-known application profiles the UK LOM Core is an optimized version of IEEE-LOM standard, designed for the use within the context of UK education and also the Can Core application profile is used in Canada. Table 3.1 shows some examples of the major application profiles along with their base scheme, number of elements and an enumeration of the educational elements field.

Table 3.1 Major educational metadata application profile

<table>
<thead>
<tr>
<th>Standard</th>
<th>Base Scheme</th>
<th>Number of Elements</th>
<th>Educational elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Network Australia (EdNa(^{25}))</td>
<td>DC</td>
<td>23</td>
<td>Type, curriculum, document, event, audience, spatial</td>
</tr>
<tr>
<td>Gateway to Educational Materials (GEM(^{26}))</td>
<td>DC</td>
<td>23</td>
<td>Audience, format, grade, language, pedagogy, object type, subject</td>
</tr>
<tr>
<td>CanCore(^{27})</td>
<td>IEEE LOM</td>
<td>30</td>
<td>Interactivity type, learning object type, semantic density, intended end-user role, context</td>
</tr>
<tr>
<td>UK LOM Core(^{28})</td>
<td>IEEE LOM</td>
<td>46</td>
<td>Interactivity type, learning object type, interactivity level, semantic density, intended end-user role, context, difficulty, relation kind, purpose</td>
</tr>
</tbody>
</table>

\(^{25}\)EdNa: [http://dublincore.org/groups/education/EdNA-Study.html](http://dublincore.org/groups/education/EdNA-Study.html)

\(^{26}\)GEM: [http://dublincore.org/groups/education/GEM-Study.html](http://dublincore.org/groups/education/GEM-Study.html)

\(^{27}\)CanCore: [http://cancore.athabascau.ca/en](http://cancore.athabascau.ca/en)

\(^{28}\)UK LOM Core: [http://www.ukoln.ac.uk/metadata/education/](http://www.ukoln.ac.uk/metadata/education/)
### 3.2.4 Minority Frameworks

In the current e-learning industry, most of the learning management systems (LMSs) work in a closed-system manner. Some of the systems are still using their own framework for learning content description rather than adopting LOM as the main standard. An XML-based format for courseware documents has been developed recently, where the courseware documents are stored in pools containing modules assembling reusable units. Modules can be structured by nested elements containing text content, tables, links, images and image animations. These educational modeling languages that are defined over XML language include: Generation of Teaching Materials (TeachML) and Procedural Markup Language (PML)

**Generation of Teaching Materials (TeachML) (Teege, G., 2002):**

TeachML has been developed in the context of the CHAMELEON project (http://chameleon-project.org/) in order to represent courseware documents is a system for supporting the preparation, use, and reuse of teaching materials. The main advantage of this approach is that, it provides an interactive presentation on the learner's side. Because TeachML documents are free of presentation aspects it is possible to create different output document e.g. an XHTML document for a web presentation and a printable version (Wehner, F., & Lorz, A. 2001).

**Procedural Markup Language (PML) (Ram, Ashwin, et. al.,1999):**

Ram et al., (1998) mentioned that, it allows the content to be represented in a flexible manner by specifying the knowledge structures, and the relationships between them using cognitive roles. The PML description can be translated into different presentations depending on factors such as the context, goals, presentation preferences, and expertise of the user.
3.3 Purpose of Metadata Specifications

The purpose of Learning Object Metadata specification is to:

- Enable learners or instructors to search, evaluate, acquire, and reuse learning objects.
- Enable the sharing and exchange of learning objects across any technology supported learning system.
- Useful for the development of learning objects in units that can be combined and decomposed into meaningful ways.
- Enable the computer agents to automatically and dynamically compose personalized lessons for an individual learner.
- Enable education, training and learning organizations of both governmental and private institutions to express educational content and performance standards in a format separate from the content.
- Provide researchers with standards that support the collection and sharing of comparable data concerning the applicability and effectiveness of learning objects.
- Support necessary security and authentication for the distribution and reuse of learning objects.

3.4 Drawbacks in Existing Approaches (Standards)

In order to make learning material identifiable by search engines they must be managed with some external descriptions called metadata. Several metadata standards have emerged for the description of learning resources. The contextual and educative-support information is an important requirement to be incorporated in currently existing educational metadata standards. From the educational domain perspective here, it is believed that there are mainly four types of issues with existing metadata approaches such as:
Ambiguity with direct use of some of the metadata elements:

Each metadata type provides specific meaning about the learning resource in e-learning applications, but the problem arises when the same metadata element is used in many contexts and a computer application is not able to make the difference, unless it is provided with some supplementary information.

For example consider the “title” element in Dublin Core and IEEE LOM metadata standards. `<dc:title>`: it says that content under this tag is title of resource but, it won’t say the meaning of title.

With reference to e-learning domain “Title” may be concept title, domain title, subject title, sub-topic title, sub title or some other else. The solution for such type of problems is the correlation of certain metadata with a certain ontology construct.

Need for more specific elements:

If the most popular IEEE LOM standard is considered, it defines 80 fields within 9 categories. The elements in these categories are not sufficient enough to meet learner requirement. For example, in educational domain the relational-metadata and the educative-support information play an important role to represent the interrelation among different categories of learning material.

Lack of Relational-metadata:

The relational metadata elements such as predecessor, successor, related topic, similar topic, etc., are some of such type of elements required for e-
learning domain, but these types of elements are not available in the existing metadata standards. Table 3.2 shows an example of relational metadata for the subject “Data-structures” in computer science domain.

Table 3.2 Relational metadata

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relational and Structural information</td>
<td>Domain</td>
<td>Computer science</td>
</tr>
<tr>
<td></td>
<td>Subject</td>
<td>Data structure</td>
</tr>
<tr>
<td></td>
<td>Topic</td>
<td>Trees</td>
</tr>
<tr>
<td></td>
<td>Sub-topics</td>
<td>Tree traversal</td>
</tr>
<tr>
<td></td>
<td>Similar-topic</td>
<td>Binary Trees</td>
</tr>
<tr>
<td></td>
<td>Related-topics</td>
<td>Graph traversal</td>
</tr>
</tbody>
</table>

Lack of Educative-support Information:

Educative-support Information is an important requirement to be incorporated in educational metadata standards that helps learner to understand well about the topic or concept through referring different supportive materials such as examples, references and application scenarios. Some of the educative-support elements are shown in Table 3.3.

Table 3.3 Educative support information

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Educative support elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>To improve understanding level</td>
<td>Example, Illustration, Application-areas, Case study etc.</td>
</tr>
<tr>
<td>For further reading</td>
<td>Prerequisite, References, Bibliography, Related topics etc.</td>
</tr>
</tbody>
</table>
3.5 Possible Approaches to Strengthen Existing Standards

Here, mentioned are three possible approaches to strengthen the metadata standards so as to make them suitable for educational domain with educative and semantic support information.

Incorporating additional elements:
As per the Dublin Core metadata standard specifications, it is possible to incorporate additional qualifiers or elements through a "new" element or property within the Dublin Core element, with more specific meaning based on domain requirements and more specialized than its parent element. IEEE-LOM also enables to add new elements as per the domain requirements, so that IEEE-LOM can be used for developing application profiles.

Semantic information through paired tags:
The University of Hull Centre for Internet Computing followed an approach to describe the context and semantics of domain through structuring the semantic information in the form of paired tags as \(<\text{predicate/object}>\) pair. It means that the metadata tags can be included along with required semantics like: \(<\text{isa, university-website}>\), \(<\text{has, academia}>\)

Through ontological approach:
Ontology technology is considered to be a highly suitable means of supporting educational-technology systems [Sampson et al., 2004] and ontologies provide more semantics to learning resources description model. The usage of one or more types of relations between concepts and using the classical semantic relations such as "is-a" and "part-of" relations between concepts will improve the precision of modeling (Brusilovsky et al., 2002).
It is believed that the ontological approach is a suitable means to enrich existing metadata standards to overcome differences in terminology.

3.6 Towards Enrichment of Existing Standards

The current e-learning standards are conceived especially for learning management purpose and not for integration with various Semantic Web applications. The semantic based standardization of important base technologies for e-learning applications is growing to become a significant force. Most of the implementers and researchers still remain with XML based technology for metadata representation, even though there are many potential benefits with semantic web technologies such as Topic Maps\footnote{http://www.topicmaps.org/} and ontologies.

Recently, the popular standard IEEE LOM is expressed in Resource Description Framework (RDF) format and the semantic information is included in the document model on the top of the IEEE LOM e-learning standard.

As shown in Figure 3.2, the educational metadata must have elements to support content, structural, semantic and contextual descriptions of educational domain. But the current metadata elements are generic terms which are not specifically designed and developed for educational domain, so that they are just useful for the purpose of content management and structural description of learning material but not much supportive for semantic or contextual description of learning resources.
To get full-fledged educative support metadata, the existing metadata must be enriched so as to support all the four layers that are shown in Figure 3.2. These four layers can be described as:

**Content:** What the learning material is about, i.e., basic information about learning object such as title, identifier, format, etc.

**Structure:** How the group of learning materials can be managed and organized with proper structural relations among the learning material.

**Semantic:** The semantic description consists of different types of interrelations among learning objects in the context of educational settings.

**Context:** Where and in which case the material is useful and in what form and how the learning material is presented.
3.7 An Ontology based Metadata

In the knowledge representation domain, the term “ontology” refers to the formal and explicit description of domain concepts, which consist of: set of entities, relations, instances, functions, and axioms. An ontological framework for representing domain specific and educative support metadata information of learning resources at the semantic level helps e-learning domain to cope with Educational Semantic-web Vision.

Ontologies have the potential to play an important role in the development of course content and they can be used to represent knowledge about content to support instructors in creating content or learners in accessing content in a knowledge-guided way (Boyce & Pahl, 2007). The ontologies for educational specific contents allow learners to acquire knowledge about a learning subject and to improve the understanding level of the learner. It is also useful for structuring and grouping the learning material as per the course and the curriculum requirements of the institution concerned. Educative support information allows the learning material to be adapted based on the learner’s knowledge level, course and standard. It also enables the learner to select suitable material as per his/her educational requirements such as scope, activities, standard, etc.

3.7.1 Ontology in learning infrastructure

In the knowledge representation domain, the term “ontology” refers to the formal and explicit description of domain concepts, which are often conceived as a set of entities, relations, instances, functions and axioms. In the computing context, ontology is a framework for representing concepts and the relationships that exist between those concepts (Uschold & Gruninger, 1996).
Gruber (2009) defined ontology thus: “In the context of computer and information sciences, an ontology defines a set of representational primitives with which to model a domain of knowledge or discourse. The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members)”.

During the recent years, the semantic technology such as ontology based representation of metadata has influenced the research in the area of educational software for accessing, searching and structuring of e-learning.
contents to provide personalized, adaptive and context aware delivery of learning content. As shown in Figure 3.3, in e-learning environment ontologies can be used at learner side (client side) and domain side (server side). In this dissertation ontological approach is used as resource description metadata to manage learning content and at learner side for modeling learner context and preferences, so as to obtain an adaptive content delivery based on learner context.

### 3.7.2 Applications of Ontology in Educational Domain

Table 3.4 shows different classes of ontologies and their respective purposes in e-learning domain. The domain ontologies are mainly used for content management purposes through annotation, structuring and organization of e-learning contents while the learner-model ontologies such as context ontologies are useful in managing delivery process such as adaptation, recommendation and presentation of contents based on learner requirements.

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of ontology</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>For managing learning materials</td>
<td>Content (domain) ontologies and Structure ontologies</td>
<td>Annotation</td>
</tr>
<tr>
<td>(Domain side)</td>
<td></td>
<td>Structuring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organization (or Management)</td>
</tr>
<tr>
<td>For managing delivery process of learning materials</td>
<td>Context ontologies and Learner-model ontologies</td>
<td>Adaptation (or Personalization)</td>
</tr>
<tr>
<td>(Learner side)</td>
<td></td>
<td>Recommendation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Presentation</td>
</tr>
</tbody>
</table>
What follows is a brief description of each purpose mentioned in the above table:

Annotation:
The general purpose of using semantic annotation in an educational context is to classify and add information to the existing learning resources, so that they can be retrieved and searched by semantic means, which make these web resources amenable for machine processing and that can help users to search for appropriate learning objects. The learning-object or any educational document that has an identifier can be annotated. There are already attempts in this direction: Annotea (Annotea Project) is a project where annotations are created locally or on a server in RDF format.

Structuring:
For semantic based accessing of learning-objects, semantics become more important within the emerging field of e-learning. In the learning context, the conceptual structure of the content is an essential part of the learning material. The structural classification category describes where the resource falls within a particular classification system. The structuring describes the learning object in relation to a particular classification system. Ontology based document-structuring format allows machine processing, enables flexible storage and retrieval based on content semantics.

Organization:
The e-learning contents should be organized with an external structure of information to facilitate their identification, storage and retrieval. The characteristics of semantic web are based on ontologies which enable the semantically enriched organization of the learning materials. In the
conception of e-learning, knowledge and information structuring is a central theme for learners as well as for teachers. The ontology-based organizational memory aims at helping them to structure and manage knowledge related to a given course or training unit. It relies on an organization model of the course unit and takes into account teacher’s and learner’s viewpoints (Abel et al., 2004).

Adaptation:

Adaptation and personalization in e-learning systems refers to the process of enabling the system to fit its behavior and functionalities to the educational needs (such as learning goals and interests), the personal characteristics (such as learning styles and different prior knowledge) and the particular circumstances (such as the current location and movements in the environment) of the individual learner or a group of interconnected learners (Wu et al., 2008). The difference between adaptation and personalization is defined by Martin and Carro (2009) as adaptivity deals with taking learners’ situation, educational needs and personal characteristics into consideration in generating appropriately designed learning experiences, whereas personalization is a more general term and deals with the customization of the system features, including issues which can be adapted and specified by learners themselves, such as the system interface, the preferred language, or other issues which make the system more personal.

30Annotea Project: http://www.w3.org/2001/Annotea/
Recommendation:
A knowledge-based recommender will typically need to know different features that are associated with learning content. The domain knowledge that a recommender can employ is an ontology over the content features; such an ontology allows the system to reason out the relationship between features. Burke (2000) mentioned that a knowledge-based (ontology-based) recommender system avoids some of the drawbacks like it does not have a ramp-up problem since its recommendations do not depend on a base of user ratings. Hyon Hee Kim (2011) presents a method for personalized recommendation services using a tagging ontology for a social e-learning system.

Presentation:
In an e-learning system environment, the format of the presentation of contents for the e-learning is expected to produce a desirable learning effect in an e-learner. Ontology can be used to capture the conceptual understanding of the domain in which presentation takes place. The ontology based document presentation will support learning in two ways. First, the conceptual structure will be conveyed to the learner so as to improve the learner’s cognitive skills. Secondly, the embedded semantic knowledge will be expressed in a natural human narrative form, to achieve effective learning.

3.8 Ontology-based Content Management

When learning materials are stored in a database, without external domain knowledge other than the database itself, it can be difficult to decide what a learning material is supposed to mean and for what requirements or preferences of learner it can be delivered. So, the learning material must be accompanied with
the respective domain ontology for modeling characteristics and conceptual learning dependencies between the resources.

Ontology technology is considered to be a highly suitable means of supporting educational-technology systems (Sampson et al., 2004). The ontological approach is a promising research domain to overcome the most common problems for intelligent applications in an educational domain (Mizoguchi & Bourdeau, 2000; Devedzic, 2003). Here, the ontological approach to represent metadata of learning resources supports adaptation-oriented resource modeling (Content modeling) that allows us to organize and index resources, so as to deliver suitable content based on the particular context of e-learner.

Learning materials are meant to be reusable in different contexts by different users and they can easily be searchable and manageable; so it needs association of suitable descriptions. The content repositories allow the learner to search and retrieve learning materials from the repository and the learner may need to search for specific content according to his personal requirements and preferences, which need the repositories to allow advanced search options.

Here, are the proposed five categories of learning material description information as shown in Figure 3.4. The metadata information needs to be considered while developing the domain ontology for e-learning materials as well as it is also useful for specific management needs of learning material to support advanced search. The learning material repository should allow the users to browse through the learning material as well as it should support simple keyword based search and advanced search to meet the specific needs and preferences of e-learner.
Figure 3.4 Categories of learning material description information

General information:
It gives primary details of learning material and leads support to keyword based search approach.

Subjective specific information:
Incorporating the subjective specific details in domain ontology prompts the search engine to find more suitable and related topics to given query.

Educational information:
This information is for searching the supportive learning material of search topic such as examples, applications and relevant references of topic.
Technical information:
Learner can get learning material with preferred technical details such as location, size and format. For example, the learner can search for his learning style formats like video, audio, animation, text, etc.

Rights information:
It provides an access control mechanism for learning resources.

### 3.8.1 Domain Ontology

The domain ontology contains information about the domain knowledge of learning content and describes the content structure. The semantic based representation of learning contents has various representation approaches, but for context aware adaptive learning environments the ontological representation of learning content metadata is much suitable. Figure 3.5 shows the partial representation of domain ontology that consists of classes (terms), sub-classes and their inter relations among domain concepts. Table 3.5 shows the formal representation of this partial ontology in OWL format, since the Web Ontology Language (OWL) is an international standard for encoding and exchanging ontology and is designed to support the Semantic Web.

![Figure 3.5 Partial representation of domain ontology](image)

Figure 3.5 Partial representation of domain ontology
Table 3.5 Formal representation of domain ontology

```xml
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
  xmlns:owl = "http://www.w3.org/2002/07/owl#"
  xmlns:rdf = "http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:xsd = "http://www.w3.org/2001/XMLSchema#">
  <owl:Ontology rdf:about="">
    <rdfs:comment>Domain OWL ontology</rdfs:comment>
  </owl:Ontology>

  <owl:Class rdf:ID="Identifier">
    <rdfs:subClassOf rdf:resource="#Learning-Document"/>
  </owl:Class>

  <owl:Class rdf:ID="Creator">
    <rdfs:subClassOf rdf:resource="#Learning-Document"/>
  </owl:Class>

  <owl:Class rdf:ID="Document-Type">
    <rdfs:subClassOf rdf:resource="#Learning-Document"/>
  </owl:Class>

  <owl:ObjectProperty rdf:ID="isCreatedBy">
    <rdfs:domain rdf:resource="#Learning-Document"/>
    <rdfs:range rdf:resource="#Creator"/>
  </owl:ObjectProperty>

  <owl:ObjectProperty rdf:ID="isPartOf">
    <rdfs:domain rdf:resource="#Learning-Document"/>
    <rdfs:range rdf:resource="#Document-Type"/>
  </owl:ObjectProperty>

  <owl:ObjectProperty rdf:ID="hasIdentifier">
    <rdfs:domain rdf:resource="#Learning-Document"/>
    <rdfs:range rdf:resource="#Identifier"/>
  </owl:ObjectProperty>

  <owl:DatatypeProperty rdf:about="Textual">
    <rdfs:domain rdf:resource="#Document-Type"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
  </owl:DatatypeProperty>

  <owl:DatatypeProperty rdf:about="Audio">
    <rdfs:domain rdf:resource="#Document-Type"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
  </owl:DatatypeProperty>

  <owl:DatatypeProperty rdf:about="Video">
    <rdfs:domain rdf:resource="#Document-Type"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
  </owl:DatatypeProperty>
</rdf:RDF>
```
The concept of Semantic Web should give an explicit meaning, so that machines can process it more intelligently, instead of just creating standard terms for concepts as is done in XML. The OWL became a World Wide Web Consortium (W3C) Recommendation in February 2004. As such, it was designed to be compatible with the eXtensible Markup Language (XML) as well as other W3C standards. In particular, OWL extends the Resource Description Framework (RDF) and RDF Schema. OWL is based on description logics; the description logics are a family of logics that are decidable fragments of first-order predicate logic. These logics focus on describing classes, roles, and semantics of the domain (Heflin, J., 2007).

3.9 Ontology-based Context Modeling

Ontologies are one of the most functional means for representing contextual data. They map three basic concepts in a context model (classes, relationships and attributes) to the existing things in a domain (de Almeida et al., 2006). Ontologies are a very promising instrument for modeling contextual information due to their formal expressiveness and the possibilities for applying ontology reasoning techniques (Baldauf et al., 2007).

The formalism of choice in ontology-based models of context information is typically OWL (Horrocks et al., 2003) or some of its variations, since it is becoming a de-facto standard in various application domains, and it is supported by a number of reasoning services. The OWL as the representation language enables expressive context description and data interoperability with third-party services and applications. By means of OWL it is possible to model a particular domain by defining classes, properties and relations between individuals.
The e-learning materials are authored by different people with different goals, for various purposes and with different domain expertise. These learning materials are accessed by learners which differ in a wide range of characteristics, requirements and preferences. In e-learning systems the learner preferences from the perspective of learning domain and educative support information, play an important role to implement successful educational applications. We are interested in achieving an ontological orientation to represent learner’s situation, domain and activity details so that it will capture all the information related to learner’s learning scenario and context. The categorization of context information
in e-learning domain (from learner perspective) as *Situation-context, Domain-context* and *Activity-context* and the relevant partial context ontology representing the learner’s context is shown in Figure 3.6 and being used by adaptation mechanism as shown in Figure 3.7. The context information has the form of subject, predicate and value. The subject is a subject of context, e.g. a Location, Learning-Media, a computing entity or an activity. The predicate represents a property of subject, e.g., *isLocatedIn, hasLearnerPref*, etc. The value represents all values of subject or subjects, e.g., city name, text, etc. The most common requirements of adaptation mechanism during the accessing of suitable learning material consist of mainly two strategies like the learning material should be related to learning domain as well as learning style and should be compatible to present on learner’s learning device.

The learner’s contextual information can be acquired through registration process (also called static approach), through user-interface during learning time (also called dynamic approach) and using context detection service (for finding device type and its capabilities). The given Table 3.6 shows partial
OWL-program with XML syntax is an example of contextual details for an adaptation scenario. An example scenario: The learner with professor role is using learning device cell-phone of Nokia model with medium screen size, Symbian operating system and 128 MB RAM.

Table 3.6 Contextual details of an example scenario in OWL

```xml
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
xmlns:owl ="http://www.w3.org/2002/07/owl#"
xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:xsd ="http://www.w3.org/2001/XMLSchema#">

<owl:Ontology rdf:about=""/>
    <rdfs:label>Learner Context Ontology</rdfs:label>
</owl:Ontology>
<owl:Class rdf:ID=" Professor ">
    <rdfs:subClassOf>
        <owl:Class rdf:ID=" Role "/>
    </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="City">
    <rdfs:subClassOf>
        <owl:Class rdf:about="#Location"/>
    </rdfs:subClassOf>
</owl:Class>
<owl:ObjectProperty rdf:ID=" usingDevice ">
    <rdfs:domain rdf:resource="# Professor "/>
    <rdfs:range rdf:resource="# Device "/>
    <rdf:type rdf:resource="http://www.w3.org/.../owl#FunctionalProperty"/>
</owl:ObjectProperty>
< Professor rdf:ID="Cyril-Raj">
    <usingDevice>
        <Mobile-Phone rdf:ID=" Nokia-C5-03 ">
            <hasScreenSize rdf:datatype="&xsd:string">Medium</hasScreenSize>
            <hasOS rdf:datatype="&xsd:string">Symbian OS v9.4</hasOS>
            <hasMemory rdf:datatype="&xsd:string">128 MB RAM</hasMemory>
        </Mobile-Phone>
    </usingDevice>
</ Professor>
</rdf:RDF>
```
3.9.1 Advantages of Ontology for Context Modeling

The reason for using ontological approach in adaptation and personalization is: it consists of powerful mechanism to support for keyword based search and advanced personalized search options. Ontology has been a basis for the construction of a user model (Middleton et al., 2002) in several personalized systems ranging from information delivery systems to Intelligent Tutoring Systems (Dicheva & Aroyo, 2000). The description of learning resources through ontology helps the adaptation mechanism to access the contents based on their semantic relationships.

Ontology is a machine processable representation of concepts so that the ontology based e-learning model can be formally represented with well-known semantic supportive standard languages like Resource Description Framework (RDF) model and Web Ontology Language (OWL). Figure 3.8 presents the semantic supportiveness of ontology representation languages XML, RDF and OWL.

![Figure 3.8 Languages for formal representation of ontology](image-url)
When dealing with context information it is always a challenge to describe contextual parameters and their relationships in a traceable manner. Ontologies seem to be well suited to represent the knowledge concerned to context in e-learning domain. Some of the advantages of ontology for context modeling are as mentioned below:

- Amount of information to be delivered to the user can be reduced based on the learner preferences and context ontology.

- The user needs and expectations can be predicted to recommend suitable material based on ontological inference mechanism.

- It enables formal analysis of domain knowledge for context reasoning from explicitly defining context ontology.

- The main purpose of ontology-based context model is to enable semantic interoperability and to provide common understanding of the structure of context information among the users.

3.9.2 Content Adaptation based on Context Model

The existing search techniques and digital learning resource management approaches are good enough for key-word based search in e-learning. The recent trend of personalized learning styles and diversity of digital learning devices has offered many challenges to learning content delivery, presentation and management system. The diversity in learner requirements, preferences, digital learning devices and different types of learning resources have raised the issues to discover and present the most suitable version of learning resources that are compatible for the relevant learning style requirements and learning device-context of e-learner.
The growing interest about adaptive and personalized learning has led to several research initiatives that investigate the educational paradigm shift from the traditional one-size-fits-all approaches to adaptive and personalized learning (Lo et al., 2012). The contextual divergence needs the context aware adaptive delivery of learning resources. A well-defined context model is an important key to access the context information of any context-aware system (Strang & Linnhoff, 2004).

The adaptation logic which is derived from context model is used to perform adaptive delivery of learning contents as per the learner context. The adaptation logic selects suitable content based on resource description metadata. Schmidt (2005) noted that, the contextual metadata needs to be provided along with the learning resources to allow efficient filtering based on learner context. The learner context model for personalized learning environment has explicit representation of semantics using ontologies. This ontology classes may contain a wide categorization details provided by the learner through user interface, from learner profile and from external learning environment detection service.

Through representing learner’s context and preferences in an ontological format, we can take advantage of ontology representation languages such as RDF/OWL to define the learner characteristics and for preserving the semantics of learner context from which the respective adaptation logic is derived.

### 3.10 Benefits of Ontological Approach

The general goal of using ontologies in e-learning domain is to increase the accessibility and the reusability of the e-learning material. Following are some of the requirements for using ontological approach in e-learning
systems. Monachesi et al., (2008) mentioned that in the LT4eL project, ontologies are employed in order to improve the reuse of learning objects available within a Learning Management System and facilitate access to objects in various languages since the ontology plays the role of an Interlingua which mediates at the conceptual level among language specific textual realizations of the concepts. Packer (1999) quoted different views of pedagogical benefits in using ontologies for e-learning domain. Wilson (2004) noted that ontologies in educational domain help to easily locate the resources which are semantically similar even though they are syntactically different. Here, some of the important benefits of ontological approach in learning domain are mentioned.

To gain common understanding:
There are heterogeneous metadata standards developed by different organizations. These metadata standards cannot work with each other. Hence, ontology based common understanding among various standards is required. This helps learners to search learning objects that are being annotated by various metadata standards.

To promote content-based applications:
Ontology helps to promote the existing content-based learning applications to semantic-aware, context-aware and personalized learning applications.

As intermediate layer:
By means of representing the learning material characteristics in an ontological format, it can act as intermediate layer between personalized learning agents and learning object repositories.
For personalization:

Adaptivity is an important characteristic in e-learning domain for course-based or personalized learning environments, where learning material is to be customized for learner needs.

3.11 Summary

Here, the issues and drawbacks surrounding the existing learning object metadata standards and the need of ontological approach have been discussed. It is believed that the existing metadata should be represented in ontological format so as to support Educational Semantic-web Vision and new set of metadata elements are to be incorporated into existing set of standards so as to support semantic, contextual and pedagogical needs of e-learning domain. Here, the researcher has discussed the use of ontology for the purpose of content management and context aware adaptive delivery of learning contents.