CHAPTER 2

RELATED RESEARCH LITERATURE REVIEW

**Objective:** This chapter investigates the various existing aspects of the ontology based context-aware adaptation e-learning environment. It provides the brief survey of the related work in the areas of research projects, learning environments and frameworks.

### 2.1 Introduction

Particularly in context aware e-learning environments there are different heterogeneous and distributed entities that must interact for exchanging users’ context information in order to provide adaptive learning services. Here, the related literature review is roughly divided into various sub headings, on various Research Projects and components of the ontology based context aware e-learning environment.

### 2.2 Related Research Projects

In this subsection some of the projects related to the e-learning domain are reviewed:

GEM Project\(^2\) - Gateway to Educational Materials (GEM) project provides a framework for publishing and searching educational resources available on the internet. It defines a semantically rich metadata profile and
domain-specific controlled vocabularies necessary to the description of educational materials. Mainly its effort is to provide educators with quick and easy access to numerous educational resources. As stated by Forger and Tickner (2004), it has long been recognized that traditional searching technologies do not meet the needs of users, particularly when they are searching for materials in distributed collections, such as those found on the internet. GEM solves this resource discovery problem through the use of meta-data. Based on research on how teachers look for educational resources, GEM developed a set of 23 elements using the Dublin Core as a base referent.

LUISA Project³ - Learning content management system Using Innovative Semantic web Services Architecture (LUISA) is a European Union research project funded under the ICT Sixth Framework Program. It describes a global framework enabling semantic search of learning resources making a heavy use of semantic technologies in order to improve e-learning system elements and to provide on-line education with intelligence. It addresses the development of a reference semantic architecture for the major challenges in the search, interchange and delivery of learning objects. The idea of LUISA is to use Semantic Web Services in the field of TEL (Technology Enhanced Learning) following the WSMO (Web Service Modeling Ontology) approach. LUISA exploits the advantages of Semantic Web Service architecture to address the development of a reference semantic architecture for major challenges in the search, interchange and delivery of learning objects in a service-oriented context (García & Pariente, 2008).

²GEM Project: http://www.thegateway.org/
³Luisa Project: http://www.luisaproject.org/
LORNet Project\textsuperscript{4} - The Learning Object Repositories Network (LORNet) project research network is actually the major Canadian project in Learning Object repositories. One of the objectives of the LORNet project is to ensure that the Learning Objects (LO) created in a learning context can be reused or reconfigured for another environment. LO metadata is used for "digital packaging" of the LOs to catalogue it for local and global identification. LORNet aims to integrate the vast quantities of learning objects that have been created over the years by educators and instructional designers. Ultimately, LORNet aims to enhance the capacity of schools and universities to develop online courses and to make it easier for students to get the materials they need to further their education. LORNet conducts research on networked repositories of learning objects as a key element in today’s major international trends in distance learning and knowledge management. The focus is on making documents, tools, and web services available for learning and knowledge management within institutions and organizations.

GRAPPLE Project\textsuperscript{5} - Generic Responsive Adaptive Personalized Learning Environment (GRAPPLE) project aims at delivering to learners a technology-enhanced learning (TEL) environment that guides them through a life-long learning experience, automatically adapting to personal preferences, prior knowledge, skills and competences, learning goals and the personal or social context in which the learning takes place. It is an EU FP7 project; it tries to stimulate the uptake of adaptive learning by integrating it into the learning management system. The basic learning paradigm that GRAPPLE supports and advocates is learning through adaptive information exploration. The aim of this project is to enrich the user models with quality ratings to support the semantic web approach.

\textsuperscript{4}LORNet Project: http://www.lornet.ca/
\textsuperscript{5}Grapple Project: http://www.grapple-project.org/
CoAKTinG Project\textsuperscript{6} - Collaborative Advanced Knowledge Technologies in the Grid (CoAKTinG) project funded as part of the UK’s e-Science Initiative on Grid computing. It has developed reference ontology to describe the domain of computer science research (Page et al., 2005); the vocabulary of ontology is able to express relationships between entities such as individuals, projects, activities, locations, documents and publications. The objective is to advance the state of the art in collaborative mediated spaces for distributed e-Science collaboration through the novel application of advanced knowledge technologies (Buckingham et al., 2002).

EDUTELLA Project\textsuperscript{7} - The open source project called the “EDUTELLA Project” is developed based on association of semantics among the learning resources. Edutella is a peer-to-peer network for searching semantic web metadata about learning objects. It enables various systems to form networks for exchange of metadata according to semantic web standards (Nilsson et al., 2004). The Edutella P2P network (Brase & Painter, 2004) used learning object annotated with a subset of Dublin core and LOM metadata using RDF(S). The learning objects were classified using domain specific ontologies. In this the Resource Description Framework (RDF) based digital resources are used for the exchange of learning objects and services (Nejdl et al., 2002). The Edutella Query Language (QEL) is an extension of datalog suitable for querying semantic web metadata expressed in the Resource Description Format (RDF).

\textsuperscript{6}CoAKTinG Project: http://www.aktors.org/coakting/
\textsuperscript{7}EDUTELLA Project: http://www.edutella.org/edutella.shtml
LIP project\textsuperscript{8} - Learning in Process (LIP) is an EU-funded research project. It aims to provide immediate learning on demand for knowledge intensive organizations through incorporating context into the design of e-learning systems (Nabeth et al., 2004). It provides highly contextualized e-learning systems addressing the needs of knowledge intensive organizations. The final goal of the LIP project is the creation of an integrated system of e-learning elements that facilitates to the users a complete contextualization of the learning process referring to an organization and its need in real time. The targeted e-Learning system is articulated around the three main components: Learning Materials - to be proposed to the learner; Domain Knowledge - able to capture the context of the organization; User Context - modeling the characteristics of the learner.

The EUME Project\textsuperscript{9} – Ubiquitous and Multimedia Environment for Education, is intended to develop an Intelligent Learning Management System (ILMS) with the aim to improve the quality of traditional teaching strategies as well as to facilitate the implementation of new learning methodologies (Sánchez et al., 2003). The ontology that is being used in EUME project is called EUME Onto. The EUME Onto (Amorim et al., 2003) is an educational ontology that mainly contains concepts related to learning resources and learning design. This educational ontology is based on metadata specifications such as EML, LOM and DocBook.

\textsuperscript{8}LIP project: http://www.calt.insead.fr/Project/lip/

\textsuperscript{9}EUME Project: http://www.eume.net
The EDUCA Project\textsuperscript{10} - uses an ontology of cultural aspects that will basically provide a sound specification of the diverse cultural aspects. Cultural aspects are preferences and ways of behavior determined by the person’s culture. In this project, the cultural aspects are just the features that distinguish between the preferences of students or professors from different regions (Motz et al., 2005). An ontology of cultural aspects is a key piece in this project for the semantic improvement of the educational resources search process.

Ontology-based Education Grid System for e-learning (OntoEdu) approach (Guangzuo et al., 2004) is an education architecture based on ontology technology, grid technology and semantic web technology. This architecture realized the concept reusability with ontology, device and user adaptability with ubiquitous computing and emphasized the need of ontology for adaptability and personalization techniques in e-learning domain. The OntoEdu ontology includes two kinds of ontology: activity ontology (AO) and material ontology (MO). AO describes all the activities and operations of education and relations and MO describes the educational content organization.

ALFanet Project\textsuperscript{11} – Active Learning for Adaptive Internet (ALFanet) is a Fifth Framework Information Society Technology (IST) project funded by European Commission that addresses the problem of effective adaptive learning. It is intended to provide a framework to address the learners’ need for activities and user-model-based content adaptation and the tutor’s need for efficiency (Rosmalen et al., 2005). ALFanet aims to build an adaptive iLMS (intelligent Learning Management System) that provides personalized e-learning based on the combination of different types of adaptation (e.g. learning routes, interactions in services, peer-to-peer collaboration and presentation) (Santos et al., 2004).

\textsuperscript{10}EDUCA Project: www.educaresearch.eu/
\textsuperscript{11}ALFanet Project: http://adenu.ia.uned.es/alfanet/
LT4eL Project\textsuperscript{12} - Language Technology for eLearning (LT4eL) is to integrate the results of the research carried out in the Semantic Web area, as well as in the Language Technology area to enhance e-learning in order to develop innovative applications for education and training (Monachesi et al., 2006). The aim of this project is to improve the effectiveness of retrieval and accessibility of learning material. Semantic knowledge, in the form of ontologies, is used to enhance the management, distribution and searchability of the learning material. The ontologies will allow for the multilingual retrieval of the required information.

2.3 Review on Framework and Approaches

In the field of intelligent web based tutoring systems, Vassileva and Deters (1998) proposed DCG (Dynamic Course Generation) approach for automatic generation of personalized course contents as per the learner’s knowledge and goals. DCG includes components for domain authoring and for automatic generation of adaptive courses on the WWW. A course produced by the DCG is interactive, it tests the learner’s knowledge and dynamically adapts to the student's progress. The main idea of the DCG is applying AI planning techniques to create a concept (content) plan of a course which achieves a certain goal concept starting from some set of initial concepts. For this purpose the DCG Brusilovsky and Vassileva (2003) used an explicit representation of the concept structure of the domain for allowing automatic generation of individualized courses according to the learner’s goal and previous knowledge, and can dynamically adapt the course according to the learner's success in acquiring knowledge.

\textsuperscript{12}LT4eL Project: http://www.lt4el.eu
The Courseware Watchdog\textsuperscript{13} is an ontology based tool that helps teaching staff and students in the search and organization of relevant learning material available on the web. It is part of the PADLR framework (Personalized Access to Distributed Learning Repositories) that builds upon a peer-to-peer approach for supporting personalized access to learning material (Tane et al., 2003). The courseware watchdog integrates, on the one hand, the Semantic Web Vision by using ontologies and a peer-to-peer network of semantically annotated learning material; on the other hand, it addresses the important problems of finding and organizing material using semantic information. It indicates how a Semantic Web based approach is better able to meet the retrieval and management of remote resources, by providing tools for discovering and organizing.

OntoAIMS (Aroyo et al., 2003) is an adaptive information searching and browsing environment that recommends to learners the most appropriate task to work on and aids them to explore domain concepts and read resources related to the task. The OntoAIMS terminology, defined by the meta-domain ontology, to specify the correspondence between concepts of the selected domain and instructional concepts needed to build a course within this selected domain. OntoAIMS uses ontologies to represent the aspects of the application semantics, to allow a strict separation of domain-dependent data, application related data and resources.

Yau Jane and Mike Joy (2007) described the architecture of Context-aware and Adaptive Learning Schedule (CALS) tool. This tool is able to automatically determine the contextual features such as the location, available time, etc. The appropriate learning materials are selected for the students according to the learner preferences and contextual features.

\textsuperscript{13}Courseware Watchdog: http://cwatchdog.sourceforge.net
Personalized E-Learning system based on Item Response Theory (PELIRT) (Chen et al., 2005) provides an adaptive learning, which consists of two parts; the front-end part is for managing communication with learner and recording learner behavior. The back-end part is to analyze learner ability and select suitable learning materials for learner based on estimated learner ability.

Adaptive Personalized Course Learning System (APCL) (Salahli, 2013): This approach allows for choosing an effective way of learning with regard to parameters such as students’ knowledge level, understanding degree, as well as the difficulty of course topics and course learning materials. APCL is based on the use of ontological knowledge about course contents and also on the application of the probabilistic methods, such as the Item Response Theory and Law of Total Probability.

The personalized multi-agent e-learning system architecture proposed by Baylari and Montazer (2009) uses an item response theory and artificial neural network to recommend appropriate learning materials to the learner through diagnosing learner’s learning activity. Agile e-learning system architecture proposed by Finke and Janis (2010) with the features such as adaptability, reusability and changeability provides an opportunity for dynamic curriculum exposition. Through considering learner’s personal features, preferences and previous actions as contextual profile, Martin et al., (2006) presented architecture of a system, based on modularization of the adaptation layer that supports context-based adaptation for m-learning.

As quoted by Daqing et al., (2006), ontology can provide the visual presentation of conceptual structure about the course topics and Dicheva and Dichev (2004) stated that the conceptual structure of the course content helps in
getting the orientation of learning task. Cantador et al., (2008) mentioned that an ontology-based representation is richer, more precise and less ambiguous than a keyword-based model. It provides an adequate grounding for the representation of learning course-material to fine-grained user interests.

2.4 Review on Ontology and Context Model

Wang et al., (2004) introduced an OWL ontology named CONON, which stands for “Context Ontology”. CONON is supposed to be used in pervasive computing environments to identify location, user activity and computational entities as fundamental context categories to enable context modeling and logic-based context reasoning.

Hong and Cho (2008) presented a conceptual ubiquitous learning architecture based on a context-aware manager. This ontology-based context model is called CALA-ONT (Context Aware Learning Architecture ONTology) which supports user-centric ubiquitous learning services. It consists of four top-level classes and sub-classes and contains twelve main properties which describe the relations between individuals in top level class and its sub properties.

In the area of learning objects, Gasevic et al., (2004) proposed an approach to enhance learning object content using ontologies and Semantic Web languages. They implemented a simple educational web application using content structure ontologies and domain ontologies to illustrate their approach and the application was based on the Petri net ontology.

Park and Jae (2007) proposed an ontology-based procedure for rule identification using “OntoRule” through eXtensible Rule Markup Language
(XRML) approach and discussed several issues in using ontology for rule identification. Bontchev and Vassileva (2009) proposed the construction of adaptation engine for rule-driven approach that allows separation of adaptive rules from business logic.

Schmidt and Winterhalter (2004) used context to retrieve relevant learning object for a given user. The matching service computes a similarity measure between the current user context abstraction and the ontological metadata of each learning object and then can present a ranked list of relevant learning objects. It is a kind of active use of context intending to reconfigure available services (learning objects).

Strang and Linnhoff (2004) analyzed several approaches in the literature according to data scheme used and concluded that ontologies are promising for context modeling. They represent explicit, formal (i.e. machine understandable) and shared conceptualization of real world aspects. Adaptive delivery based on the learner context model allows improved readability and understandability of the learner. Shute and Brendon (2003) noted that, in the context of adaptive e-learning the adaptation decision relates to customizing the content as per the learner context model. Ramadhanie et al., (2009) considered learner’s prior knowledge, learning style and performance aspects of the e-learner, for obtaining semantic based adaptation in e-learning environment.

According to Sieg et al., (2007) user interests are the main feature of the user’s profile; it indicates background information of user like topics of interest, familiarity with the query topic, preferences, etc. This can be represented in the form of semantic structures enhanced with the use of ontologies.
Ribeiro et al., (2006) stated the way users perceive quality (Perception) and define their satisfaction level. Personalization ontology-model defines user perception; the concepts in ontology represent user’s application specific purposes (Goal) and properties in ontology establish relationships between these concepts.

Lee et al., (2005) have developed a Java Learning Object Ontology for an adaptive learning tool to facilitate different learning strategies and paths for students which can be chosen dynamically. Mohan & Brooks (2003) proposed three different types of ontologies related to learning objects such as domain ontologies to cover subject area, ontologies that cover learning and teaching strategies and ontologies for structuring of learning objects.

The resource description metadata allows searching and retrieval of suitable learning content (Laroussi, 2012). Ontology is a knowledge representation approach that describes the knowledge through defining concepts along with their properties and relationships (Wilson, 2004). The hierarchical content presentation helps learner to navigate through related concepts of current learning concept. “AdaptWeb” (de Freitas et al., 2002) project offers adaptive content presentation of course contents associated with specific course and this adaptation approach is based on particular student profile.

Aroyo et al. (2006) proposed ontology based dialog system called OWL-OLM, for acquisition of user knowledge and to analyze the current state of the user’s knowledge according to the needs for a particular course task.
2.5 Review on Context aware E-learning

Mobile devices are recognized as an emerging technology with the potential to facilitate teaching and learning strategies that exploit individual learners’ context (Jeng et al., 2010); this has initiated the educational paradigm to shift from the traditional one-size-fits-all approaches to the context aware adaptive and personalized learning approach. Bouzeghoub and Lecocq (2007) proposed a situation-aware framework and mechanism which takes into account such as time, place, user knowledge, user activity, user environment and device capacity for adaptation to user.

Bomsdorf (2005) developed a system prototype to present educational resources to the learners by transforming the format, the type and the dimensions of educational resources based on the type of learner’s mobile device, the learning style and the learner’s preferences such as location, time available for learning, concentration level, etc. A prototype context-aware mobile learning system has been developed by Gómez et al., (2012), which semi-automatically adapt individual learning activities based on the dimensions of learner’s contextual information and describes a tool for delivering adaptive and context-aware educational scenarios via mobile devices.

A context-aware mobile learning system proposed by Al-Mekhlafi et al., (2009) is called Context-aware Mobile Chinese Language Learning (CAMCLL). The proposed approach includes four contexts (time, location, activity, and learner level). In this the ontology-based matching with the combination of rule-based matching is a special feature in building matching mechanism.
PCULS (Chen & Li, 2010) is a context aware mobile learning system that is designed to support English vocabulary learning and selects appropriate educational resources for presenting them to the learner. It exploits appropriate context based on learner's location, leisure learning time, and individual abilities to adapt learning contents towards learners for promoting the learning interests and performance.

The context - aware mobile learning prototype architecture called CAMLES system is proposed by Nguyen et al., (2010); it adapts the sequence and navigation of its educational resources for different learners based on context - awareness such as combination of learner’s previous knowledge, needs, preferences, availability, current location and learner’s temporal information. This prototype allows the learner to learn adaptive materials for TOEFL test anytime anywhere with mobile phone.

2.6 Related Learning Environments

In formal education, a curriculum defines instructional content, materials, resources and means with which students will interact for the purpose of achieving identified educational outcomes. Following the emergence of the Internet many portals, tools and Virtual Learning Environments (VLEs) have been developed with the aim of supporting learning and teaching activities across the Internet. However, Moodle and Blackboard are the most popular online learning platforms with which educators can develop complete online course that can include multimedia content. To explore some of these benefits of our proposed approach, here we try to perform brief comparison of various feature wit reference to Blackboard and Moodle virtual learning environments as shown in Table 2.1.
Moodle:

Moodle\textsuperscript{14} is this free, open-source, learning management system wherein educators can create online learning environments for their students. It is what high schools and colleges use to offer online classes. Educators use the program to distribute notes and resources, implement quizzes, set up forums and chats, and build an online community around their subject matter. Moodle is a free and open-source software learning management system. Moodle is used for blended learning, distance education, flipped classroom and other e-learning projects in schools. No context and semantic delivery mechanisms is implemented. It allows participants to do a Google like search.

Blackboard:

Blackboard\textsuperscript{15} Inc. provides powerful and easy-to-use systems for educational instruction. The Blackboard Learning System allows the instructor to accomplish effective online teaching principles. The Blackboard Learning System provides the course management system for classroom and online educational assistance. Blackboard Learning System in distance learning, hybrid courses, and as didactic supplements to other electronic environment enhancement systems (Bradford, et. al.2007). It is a virtual interactive learning environment. It does not recommend the learner with related learning material.

GeoGebra:

GeoGebra\textsuperscript{16} is an open source; it is multi-platform mathematics software (Hohenwarter, Markus, et al. 2008). GeoGebra is available with its desktop applications and with its tablet apps for Android, iPod and Windows. It is interactive mathematics software for learning and teaching mathematics and science from primary school up to university level.
Wolfram Alpha:

Wolfram Alpha\textsuperscript{17} is an internet service, which allows the use of the services on smart phones or tablets to solve mathematical problems. It offers the possibility of step-by-step presentation of solutions. By using Wolfram Alpha, students can get some other ideas, by examining the set of solutions that the service provides.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Blackboard</th>
<th>Moodle</th>
<th>Proposed Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>It facilitates online teaching and learning.</td>
<td>It facilitates online teaching and learning</td>
<td>Proposed to facilitate online learning.</td>
</tr>
<tr>
<td>Personalization</td>
<td>Students have a personal home page that lists all courses in which the student is enrolled.</td>
<td>Students can subscribe to RSS feeds to get changes to materials.</td>
<td>Students permitted to learn any concept.</td>
</tr>
<tr>
<td>Access restriction</td>
<td>Course calendar Restricted access</td>
<td>Course Restricted access</td>
<td>No Course Restriction</td>
</tr>
<tr>
<td>Role of a teacher</td>
<td>Teacher plays the role of mentor.</td>
<td>Teacher’s role is not required.</td>
<td>Teacher’s help is not required.</td>
</tr>
<tr>
<td>File organization</td>
<td>It has a multi level folder like structure very similar to Windows</td>
<td>It has single page unit based structure</td>
<td>Proposed hierarchical based structure</td>
</tr>
<tr>
<td>Device context detection</td>
<td>No context detection mechanism is available</td>
<td>No context detection mechanism is available</td>
<td>Automatic device context detection mechanism</td>
</tr>
</tbody>
</table>

2.7 Summary

In this chapter, we have performed the related literature review on various research projects, learning environments and on the components of the ontology based context aware e-learning environment.

\textsuperscript{14} Moodle: https://moodle.org/
\textsuperscript{15} Blackboard: www.blackboard.com/
\textsuperscript{16} GeoGebra: http://geogebra.org/
\textsuperscript{17} Wolfram Alpha: http://www.wolframalpha.com