CHAPTER 9

CONCLUSIONS AND FUTURE WORK

**Objective:** This chapter gives a brief description of this research work and presents overall conclusions by highlighting the contributions of this dissertation besides including suggestions for future research directions.

9.1 Review

This work aimed at developing an ontology based framework for implementing a context aware adaptive e-learning system in device independent course based e-learning environment. Previous content adaptation and personalization approaches were investigated in order to identify expedient and viable techniques. Work related to ontological approaches for content management and context modeling was also investigated. A framework was proposed through assimilating the information obtained from reviewing previous implementations and offering new strategies and views.

The Context aware Adaptive Learning Resource Ontology (CALRO) was proposed based on the information obtained from reviewing previous implementations. The context detection and description mechanism was discussed in order to give substance to the framework and to obtain adaptive functionality. The semantic knowledge based rules (nominative rules) were developed for assessing the viability of the proposal. This platform formed the basis for evaluating the framework.
9.2 Description of Research Work

The central topic of the thesis is developing ontology-based framework and prototype architecture to obtain semantic based context aware adaptive e-learning. The technical outcome of the research is the personalized delivery of the learning material, through considering learner profile (learner background), activity (learning style and learner preferences) and context (learning environment). The proposed system has been designed, implemented and analyzed.

Here, the researcher identified the purpose and goals of the Learning Object Metadata standard specifications and classified the characteristics and application profiles of well-known metadata standards of educational domain and investigated various existing LOM standards and the need for metadata enrichment. Finally, some educative support metadata elements (new extensions to the existing standards) along with their ontological representation were proposed. It is believed that educative-support information is an important requirement to be incorporated in educational metadata standards that helps the learner to understand the topic or concept better through referring different supportive materials such as examples, references, application scenarios, etc.

The primary advantage of the proposed ontology based context model is: it contains a hierarchical content structure and semantic relationships between concepts. It can provide related and useful semantic based context information for searching learning material in context-aware e-learning environment. As the ontological expression ability is insufficient to provide efficient adaptive delivery of learning material, the researcher has used the semantic knowledge based rules (nominative rules) that are derived from an ontological learner context model to enhance the efficiency in adaptation process.
The proposed adaptation oriented resource ontology is based on three different dimensions of contextual information that may help context model designers of device independent adaptive e-learning system. It is believed that the proposed Context aware Adaptive Learning Resource Ontology (CALRO) enables the discovery of suitable learning resource based on device capabilities and learning style of the e-learner. The extensive features of CALRO enable the learner to extract and understand complete details of relevant learning topic and help to improve learner understanding level through providing related knowledge of the chosen topic.

9.3 Overall Conclusions

The research report is presented to meet the following objectives:

- To understand the characteristics and drawbacks in current metadata standards of e-learning domain, the researcher has discussed the issues surrounding the existing metadata standards and the need for ontological approach to enrich existing standards.

- To manage learning material, an ontology based adaptation-oriented resource description model with educative support metadata has been introduced and it is called “Context aware Adaptive Learning Resource Ontology (CALRO)”.

- To provide context-aware personalized delivery of learning material, the ontology based adaptive learner model has been developed, through incorporating learning environmental context information such as device context to determine the appropriate presentation environment.
To achieve context-aware adaptive delivery of learning material based on learner’s context, the context detection, description and adaptation mechanism based on different contextual dimensions has been discussed and relevant prototype architecture based on MVC design pattern has been developed.

To estimate the effectiveness of the proposed prototype architecture, it has been implemented and tested on different types of learning devices and an analysis of its performance and usability has been carried out.

9.4 Evaluation of Research Questions

In this subsection some of the research questions (with answers) on which special focus is set in this research work are mentioned.

a. How to get the personal details, preferences and learning style of learner?

During registration process the user interface provides an environment to enter the personal details, preferences and learning style of the user based on which the system will deliver the relevant material. Learner’s database is maintained to store the particulars and is updated according to the learner’s requirement. Most of the details from the learner profile can be considered as static because for any particular learner the personal details such as location, identification, organization, etc. do not change during the learning process.

b. How is the learning material organized and managed so as to make it compatible for semantic based search?

Learning materials are meant to be reusable in different contexts by different users. The learning materials are associated with suitable descriptions so
that they can easily be searchable and manageable. The learning material repository allows the learner to search for and retrieve learning materials from the repository.

The learning material repository should allow the users browsing through the learning material as well as support simple keyword based search and advanced search to meet the specific needs and preferences of the e-learner. The ontological framework presented here is useful in strengthening metadata of learning resources and making e-learning domain cope with semantic based search.

c. **How is the personalization obtained?**

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 that differ in a wide range of characteristics, requirements and preferences. The proposed learner context-ontology and adaptation mechanism facilitate the extraction and the delivery of contents under the context of particular domain.

d. **How is the system analyzed?**

As a proof of concept, the proposed prototype has been implemented to provide personalized delivery of learning material to the end user. To achieve effectiveness of the proposed system a qualitative evaluation of the performance of the system and the learners’ satisfaction level has been made.

The proposed prototype was implemented in an educational organization to evaluate its performance. The experiment was performed in an
intranet enabled environment using local university database as data-set for learning materials. The outcome of qualitative evaluation showed that the learners felt that it is more convenient and yielding more effective results.

9.5 Future Research Work

Even though the proposed hypothesis and prototype presented in this thesis has achieved its intended goals, there are many potential extensions that can enhance the performance and output. However, we therefore suggest that an important future research should be:

Regarding the automatic detection of learning styles, this thesis proposed the concept of learner personal profile which does not change during learning process (Static-context: Section 4.3.1 and Section 5.6.3). The conducted research can be seen as the basis for the development of a dynamic student modeling approach, in which the information about students’ behavior and learning styles are processed immediately and the student model is updated frequently. Furthermore, the cognitive abilities such as associative learning skills can be investigated with respect to learner’s potential and learning styles.

Another aim of future research will be: to extend the concept for providing the adaptation mechanism through detection of environmental context information and reorganization of learners’ emotion, which may enhance the quality and the usefulness of the delivered learning content.

One more important aim of the future research work is to extend the proposed system to provide cognitive-based learning environment so as to make the learner to improve understandability and problem solving skills. It needs an
expected useful insight into the metadata for managing learning repositories that synthesizes a number of cognitive and instructional theories.

### 9.6 Challenges and Limitations

Despite the promising features of this approach, there remain some challenges to the ontological representation of metadata for context aware e-learning environments. Subsequently, there are some limitations of this research work.

On one hand, the ontology used for this work is purely manually populated. There are some drawbacks in manual development of ontologies. First of all, the efforts needed to build ontology for a domain requires a great effort from the ontology builder. Again the quality of the created ontology largely depends on the expertise of the domain expert who builds the ontology. These drawbacks can be eliminated by automatic acquisition of ontology (Gomez-Perez, 2003). This has got several advantages over manual authoring of ontology.

As the researcher has worked on a small subset of pedagogic metadata; if the system is developed through identifying the pedagogical features of resources and considering more metadata attributes, that may help in improving the system to provide materials to fulfill the understandability and learning goal of a learner.

Another limitation of the research work is, it is not incorporating the information about cognitive traits and learner’s selection in the structuring of e-resources to facilitate self-directed learning to make the learner find the required
information independently. Secondly, the motivational states of students are not considered to promote the learning process.

The major target group of the proposed system is mainly university students; it might be interesting to confirm our results with pre-university course students as test persons. A follow up study is needed to overcome some of the limitations and challenges of the research work.