DESIGN OF LEARNING OBJECT ONTOLOGY FOR THE DATABASE COURSE

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Abstract: *This paper presents an ontology model for a Database course, which describes the organization of reusable learning objects for an adaptive eLearning environment. Of particular interest is to define learning objects for all the key concepts defined in ACM and IEEE Computer Society's Information Technology 2008 Curriculum Guidelines for Undergraduate Degree Programs for the Database course. The presented model shows how learning objects can be organized in order to support inheritance relationship and dependencies among learning objects, making the realization of different learning paths easier.*

Keywords: *eLearning, distance learning, learning object ontology, ontology, knowledge sharing*

1. INTRODUCTION

ELearning has become an important part of formal and informal education. Throughout the years eLearning has evolved with technology and the World Wide Web. ELearning is not only used for online courses for universities, but it is also used by companies for informal education of its employees, as well as a platform for sharing learning material even for traditional students. With this evolvement and the spread of usage of the eLearning in the society, learners' demographics and their needs and preferences have also changed. The changes in the learners' demographics have started a new trend in which the learner requires more autonomy and interaction in their learning, hence, requiring the learning methods to be more adaptable to each individual learner. There are various approaches that can be used to implement adaptive eLearning. Personalization can be done based on the learner's input, preferences, learning styles, educational background, etc[1]. Ramadhanie et. al. proposed an adaptive learning objects model focusing on the ontology using the appropriate semantic information [2].

Personalization of learning for each individual learner is an effective way to improve online learning. In order to be able to have a system that can be adaptable to each learner, learning objects should be stored in the system in such a way so that they can be reused. Such flexible system is a base for an effective and adaptable eLearning system. Wang proposed a model for pedagogical design for ontology of learning objects repositories [3]. In his work he emphasized that for ontology model that domain analysis is critical. Also, in his work he pointed out that ontology does not replace meta-data of individual learning objects, but rather represents a necessary aid. Lee et.al. have proposed an ontology model for organizing learning objects for a Java course in an adaptive eLearning environment[4].

In order to introduce concepts of any course given in the IT curriculum, different learning paths can be taken, as each teacher may implement different teaching strategies. The objective of this work is to develop an ontology model for the key concepts for the Database course, which will allow implementation of these learning objects and their reusability within the learning environment.

The focus of this paper is developing ontology for a database course based on Association for Computing Machinery (ACM) and IEEE Computer Society's Information Technology 2008 Curriculum Guidelines for Undergraduate Degree Programs [5]. This paper is organized as follows: Section 2 describes a model used to develop learning object ontology and dependencies between concepts, topics and learning objects. Section 3. Demonstrates the implementation of the described ontology model. The ontologies for the key concepts of Database course are given. Section 4 concludes the paper.

2. LEARNING OBJECT ONTOLOGY

Ontology is a science that studies explicit formal specifications of the terms in some domain of interest. These formal specifications of the terms are often considered to be concepts, relations, functions and instances [6]. In this work, we refer to ontology as a formal description of concepts in a particular domain, where ontology is defined on several levels, starting from one domain and branching it out to its smaller concepts and components. We use properties of each concept to describe its features and granulate each concept to its smallest components, which we refer to as learning objects (LO). In terms of a course that is taught online, it is necessary to define its ontology carefully, from the concepts on the highest level, all the way to its smallest components, learning objects. In order to be able to reuse this knowledge in a knowledge-based program, such as eLearning system, we refer to a learning object as a smallest unit of a concept.

The main objective is to provide a well-structured and organized learning system that will support adaptive learning through reusability of learning materials. In order to be able to have an adaptive eLearning system with semantic-based domain and topic search it is necessary to have several ontology components built in a hierarchical architecture. Main three ontology layers are Curriculum Ontology, Course Ontology and Concept Ontology (Figure 1).

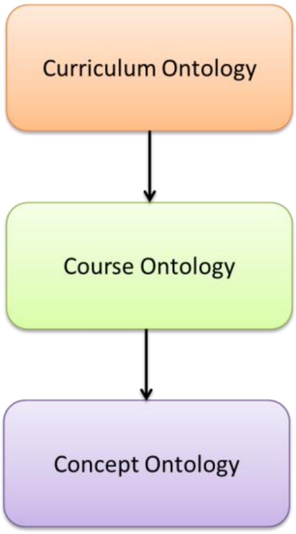

Figure 1. Ontology based eLearning system

Curriculum ontology conceptualizes the knowledge of curricula concepts such as program of study, course contained in the program, key concepts, goals of program, and body of knowledge that should be obtained in that program. Course ontology outlines the concepts that are studied in the course. These concepts are defined by the course syllabus. Each concept covers several topics. In order to achieve reusability of learning materials, each topic may be further divided into smaller units, which we refer to as learning objects (LO). This structure is shown in Figure 2.

Each portion of the given ontologies should be properly indexed for a later purpose of searching and reusing the learning material. For this purpose, all of the elements in the designed ontology can also include metadata, which is information about the element itself. This metadata can contain title, author, major, education level, level of difficulties, interactivity level and type, copyright, etc. By using metadata, learning material searching and identifying becomes easier since it can contain various information which can be used as identity for a certain learning object. In the context of the described ontology mode, Table 1 summarizes metadata that can be used for each component represented in Figure 2.

Part of the well-defined structure within course and concept ontology is to define the relationship among all components. This relationship is defined in three statuses: *prerequisite*, *mandatory*, and *optional*. As shown in Figure 2, ontology is structured as a tree, which can be analyzed from a top-down approach starting with a curriculum, and finishing with learning objects. Each concept topic and learning object should have a specified attainment level and its prerequisites. Attainment level defines whether a learning object is mandatory or optional, while prerequisites define learning objects, topics or concepts that must be learned in order to gain necessary prerequisite knowledge before studying that particular learning object.

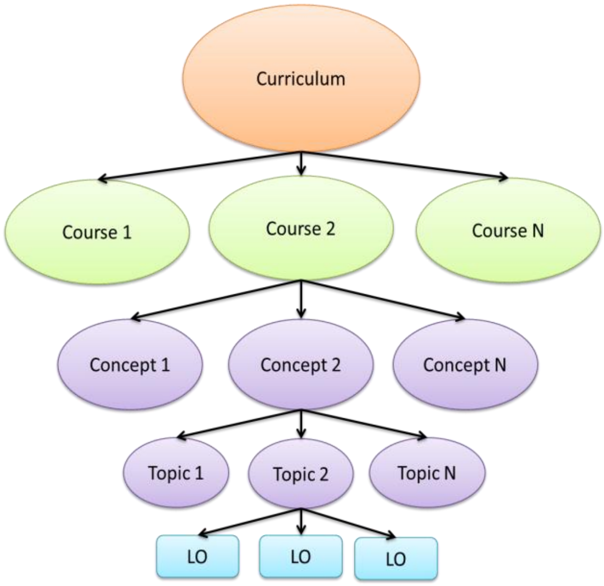

Figure 2. The structure of eLearning system ontology

Table 1. Metadata for ontology based eLearning system

Component	Metadata
Curriculum	*name, attained goal, version*
Course	*name, author, version, grading policy, prerequisites, attainment goal*
Concept	*name, attainment goal, attainment level, prerequisite*
Topic	*name, attainment goal, attainment level, prerequisite*
Learning Object (LO)	*name, author, creation date, version, last modified, attainment level, keyword, prerequisite, level of interactivity, instruction method*

Figure 3 illustrates the relationship between learning objects, which need not necessarily be from the same concept or a topic. In order to represent that a learning object is *mandatory* AND-GATE is used, while OR-GATE is used to represent *optional* learning objects. In this tree-like structure, it is easy to notice which learning object represents a prerequisite. For instance, in order to be able to study LO6 it is necessary to learn both of its mandatory learning objects LO1 and LO2. Also, LO8 represents optional learning object that is recommended only for students who want to further expand their knowledge in an optional or advanced topic, hence, it is represented as an output to an OR-GATE. At the same time, LO7 represents a mandatory learning object and it is represented as an output of an AND-GATE.

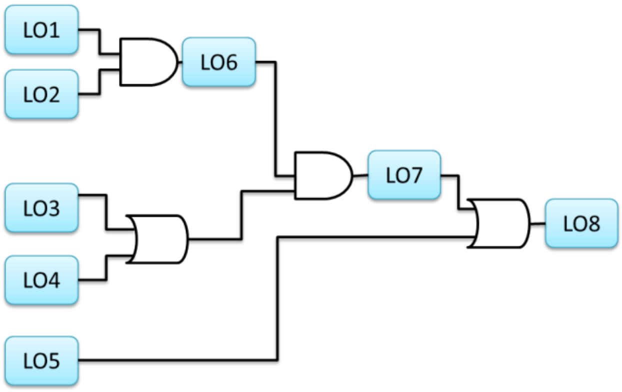

Figure 3. Example of *prerequisite*, *mandatory* and *optional* relationships among learning objects within one concept and topic

3. IMPLEMENTATION OF LEARNING OBJECT ONTOLOGY FOR DATABASE COURSE

According to ACM and IEEE IT Curriculum Guidelines IT curriculum is defined with fundamental, advanced and optional courses. Each course is specified with key concepts, which are further subdivided into topics. Topics are the lowest level of the hierarchy according to the curriculum guidelines. Of particular interests are the recommended concepts and topics for Database course. ACM and IEEE IT Curriculum Guidelines defines six key concepts: *Information Management Concepts and Fundamentals*, *Database Query Language*, *Data Organization Architecture*, *Data Modeling*, *Managing the Database Environment*, and *Special Purpose Databases*. In order to be able to implement previously described ontology model, where the smallest units are learning objects, we have further divided each topic into a subtopic, and when needed, we have divided subtopics into learning objects. Ontology for each of these concepts will be separately defined and discussed.

The ontology for the key concept *Information Management Concepts and Fundamentals* is shown in Figure 4 to the far left of the graph. The objective of this concept is to introduce the use and value of a information system, the characteristics of the database system, the data quality, accuracy and timeliness, explanation how absence of the data quality will impact organizations, mechanisms for data collection and their implications, and basic issues of data retention, including the need for retention, physical storage, and security. This concept covers the following topics: (a) purpose, use and value of information systems, (b) database systems, (c) data properties, (d) data collection, (e) data retention, (f) information backup and recovery. In order to achieve a higher level of reusability of the learning objects, some of the mentioned topics are divided into smaller units. For example, topic *Database system* contains three subtopics: (a) key terms (b) advantages of a database approach, and (c) general types of databases. As seen in the figure, *Key terms* and *General types* of databases are subtopics which are further granulated into smaller components, while *Advantage of a database approach* is not further granulated and it is represented as a learning object. Learning objects that form the subtopic *Key terms* are *information*, *data*, *database*, *database management system*, and *metadata*. On the other hand, a subtopic General type of databases contains four learning objects: *personal*, *workgroup*, *department*, and *enterprise*.

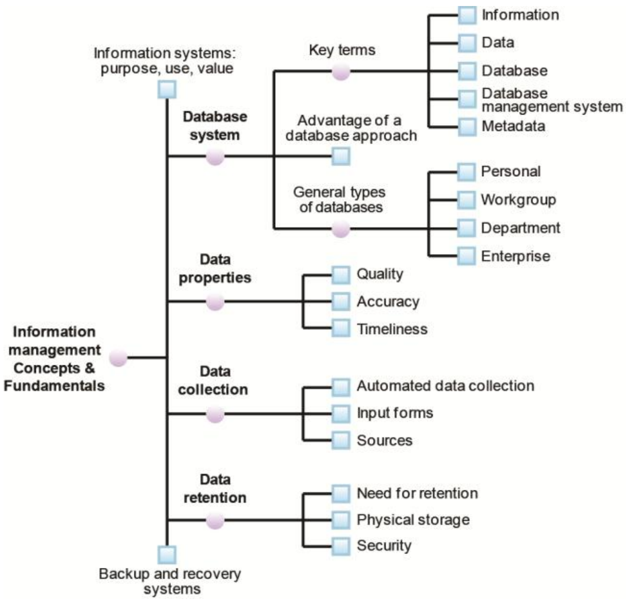

Figure 4. Ontology of the concept *Information Management Concepts and Fundamentals*

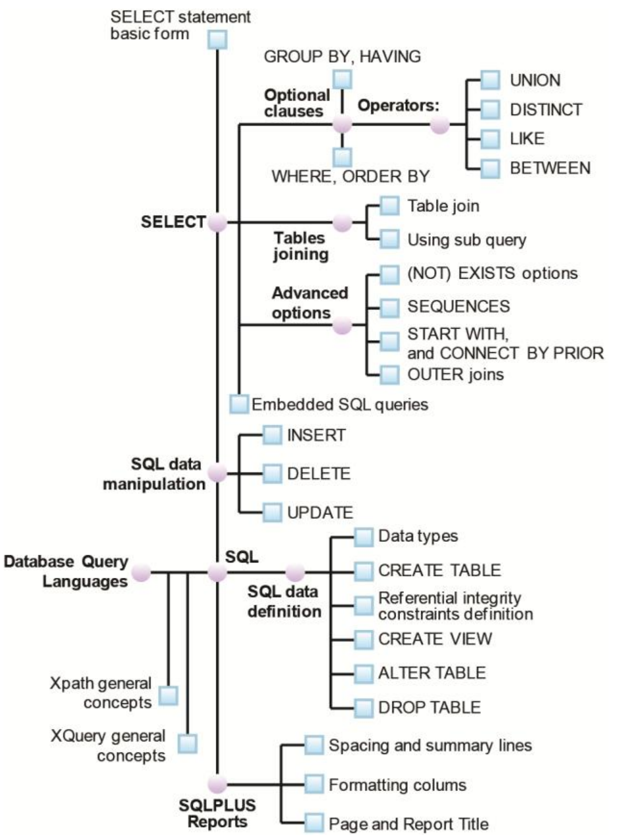

Figure 5. Ontology of the concept *Database Query Language*

Database Query Language concept describes three data query language: *SQL*, *XQuery*, and *XPath* as shown in Figure 5. *XQuery* and *XPath* are query languages used for selecting nodes from an XML document, which in database course are described globally and are represented as learning objects. The *SQL* topic, is examined in detail since SQL represents a language for relational databases retrieval and is of great importance. *SQL* contains following subtopics: (a) *SQL data manipulation*, (b) *SQL data definition*, and (c) *SQL*PLUS reports*.

The topic *SQL Data Manipulation* describes the characteristics of SQL commands used to retrieve, insert and modify database information. These commands are used by all database users during the routine operation of the database. The SELECT command is the most commonly used command in SQL and it is covered by subtopic *SELECT* in Figure 5. SELECT command can be applied in one or more tables with different clauses and options. The subtopic *SELECT* is further granulated into three subtopics and two learning objects. Three subtopics are *Optional clauses*, *Tables joining*, and *Advanced options*, while two learning objects are *SELECT statement basic form* and *Embedded SQL queries*. INSERT, UPDATE, and DELETE are commands in SQL used to add records to an existing table, modify information contained within a table and remove a record from the table, and are represented as learning objects of the topic *SQL Data manipulation*. The topic *SQL Data Definition* contains necessary information about creation and destroying of databases and database objects. These commands are primarily used by database administrators during the setup and removal phases of a database project. Four basic DDL commands are: CREATE TABLE, CREATE VIEW, DROP TABLE, and ALTER TABLE, and are the reason why they are represented as learning objects of *SQL Data Definition*. The goal of the *SQL*PLUS* topic is to format output (header, footer, totals, subtotals, etc.) reports using SQL options and post-processing features of environments like SQL*Plus.

One of the primary goals of the concept *Data Organization Architecture* is to give a brief history of database models and their evolution, describe the features of the relational model and operations such as *select*, *project*, *union*, *intersection* and *natural join* and list similarities and differences between object-oriented and relational database concepts and features. In order to achieve this goal this concept contains subtopics *Data Models*, and *Normal Forms*, and learning objects *Referential integrity* and *Entity integrity*. In Figure 6 it can be seen that subtopic *Data Models* is subdivided into eight learning objects: *Hierarchical model*, *Network model*, *Object databases*, *Object-relational databases*, *XML/XMI databases*, *Semantic models*, *Dimensional models* and *Star schema*; and one subtopic *Relational model* which is further granulated in two subtopics and nine learning objects. The topic *Normal form* contains the following learning objects *Functional dependencies*, *1NF*, *2NF*, *3NF*, *BCNF*, *4NF* and *5NF*.

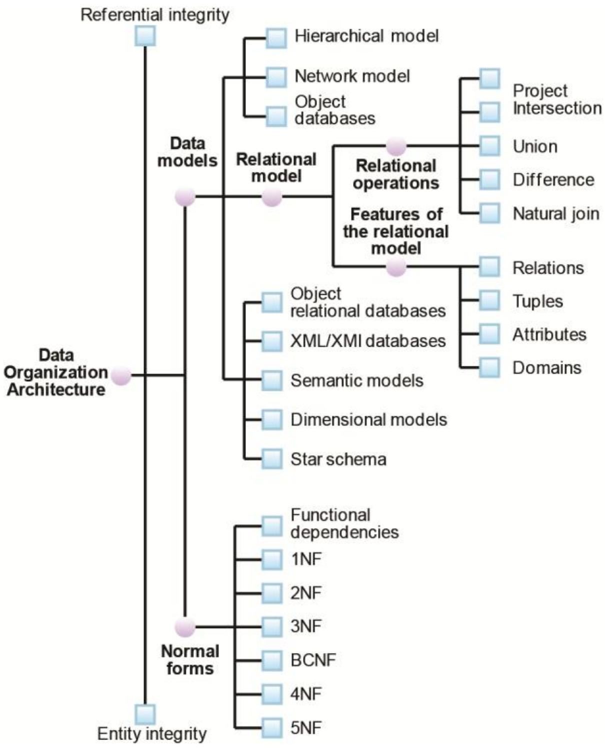

Figure 6. Ontology of the concept *Data Organization Architecture*

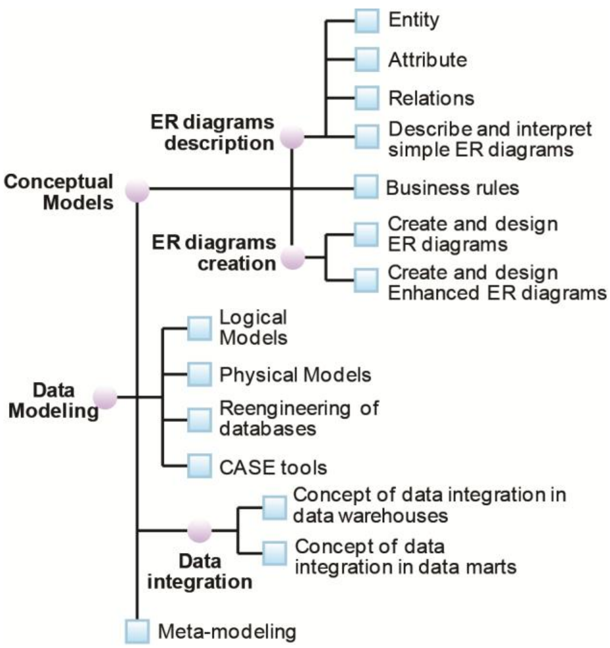

Figure 7. Ontology of the concept *Data Modeling*

The objective of the *Data Modeling* concept is to cover the presentation and interpretation of conceptual modeling, the relationship between a conceptual, logical and a physical model, to demonstrate reengineering of databases, to explain CASE tools, to give description of data integration concept and its usage in the data warehouses and data marts (Figure 7). The main technique for presentation of data models are Entity

Relation (ER) diagrams. Since ER has a high importance in Data Modeling, it is represented as a subtopic of the *Conceptual Models*. The building learning objects of *ER diagrams description* are entities, relationships, and attributes.

The concept *Managing the Database Environment* includes topics: *Database administration*, *Distributed databases*, *Client-server databases*, and *n-tier databases* as shown in Figure 8. *Client-server databases* and *n-tier databases* are not further divided into subtopics, and are considered to be also learning objects. *Database administration* covers the following subtopics: *Concurrency*, *Security* and *Backup and recovery*. In order to understand the subtopic *Concurrency*, the concept of database transactions, different concurrency control mechanisms and the need of concurrency control needs to be introduced. Within the topic *Security* different security protocols are presented. In information technology, a backup refers to the copying and archiving of computer data. Data recovery may be the only way to save information that is no longer accessible. This is the reason why special attention is given to two recovery procedures: *rollback* and *rollforward*.

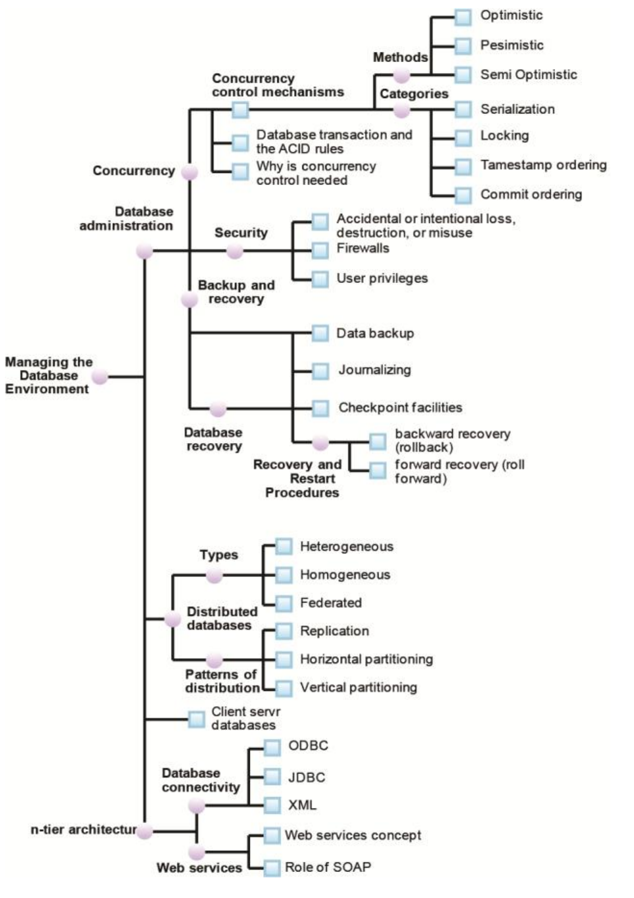

Figure 8. Ontology of the concept *Managing the Database Environment*

The topic *Distributed Database* distinguishes between the types and patterns of distribution, which introduces following learning objects in the ontology: *Heterogeneous*, *Homogeneous* and *Federated* databases, *Replication*, *Horizontal* and *Vertical* partitioning. The topic *Client-server Database* describes client-server architecture. Topic *n-tier database* describes n-tier database architecture, explains the role of ODBC, JDBC and XML in the implementation of an n-tier database architecture, describes the concept of web services and the role of SOAP in this environment.

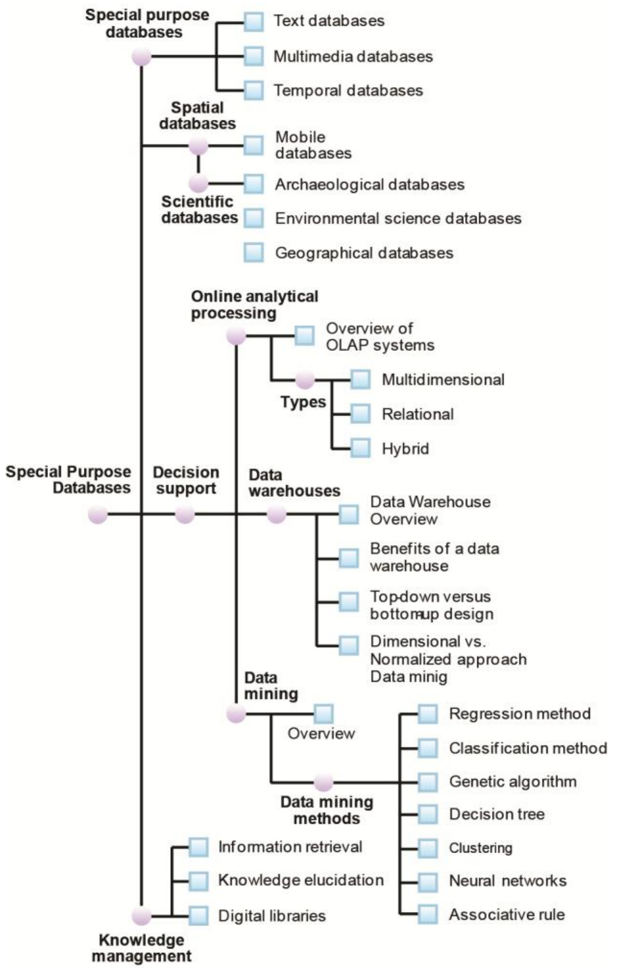

Figure 9. Ontology of the concept *Special Purpose Databases*

The concept *Special Purpose Databases* should give the basic knowledge about (a) concepts involved in special purpose databases such as full-text, multimedia, temporal, spatial, scientific, mobile and other similar database types, (b) online analytical processing, data warehouse and data mining systems, and (c) knowledge management system. This knowledge can be acquired by studying topics: *Special purpose databases*, *Spatial Databases*, *Decision support* and *Knowledge Management*. Each of these topics is divided into appropriate subtopics as shown in Figure 9.

Once the ontology for all of the key concepts is defined, we can proceed with definition of prerequisites for each learning object. As described in the model inheritance of each learning object may not only be strictly defined within the concept and the topic, but it may also have it prerequisite learning objects from other topics and concepts. Such an example is shown in Figure 10 where learning objects that are a mandatory prerequisite are shown with AND-GATE, and optional prerequisuits that can be used to further expand learner's knowledge are shown with OR-GATES. *SQL data definition, Optional clauses, Tables joining* and *Advanced options* all represent the subtopics in the concept *Database query languages*, while the learning object *Physical model* is defined within the concept *Data Modeling*. However, in the case of Advanced options and Tables joining all of their learning objects are defined as an optional prerequisite for INSERT, while for Optional clauses and SQL data definition only the indicated learning objects and subtopics in the figure represent the prerequisits. Such inheritance tree should be specified for each concept, topic and learning object.

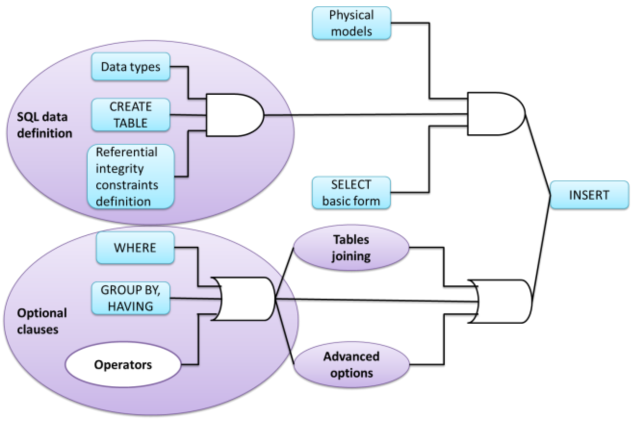

Figure 10. Learning objects inheritance and their prerequisits

4. CONCLUSION

In this work we have proposed an ontology model that can be used for an adaptive eLearning environment. In particular, a detailed ontology was given for the Database course. The shown model focused on the reusability and sharing of learning objects, which can be easily used for other curricula and courses when needed. Future work should introduce the concept of lessons, where each lesson should be defined with specific topics and/or subtopics. Since the learning paths may be different, this should ideally be done by the course instructor. Furthermore, learning object inheritance should be fully defined for all learning objects in order to allow their easier and more effective reusability. Part of the inheritance model should also define methods of assessment, which will effectively determine whether the prerequisite knowledge is successfully learned.

5. ACKNOWLEDGMENT

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