SQL Learning Object Ontology for an Intelligent Tutoring System

Wilairat Yathongchai, Thara Angskun, and Jitimon Angskun

***Abstract*—This paper presents the development of learning object ontology for SQL contents that are designed according to the computer science curriculum standards of the ACM / IEEE Computer Society 2013. The learning object schema was designed by using the SCORM and the Ontology approach. The learning objects can be used as the knowledge base of Intelligent Tutoring System. The major characteristics of them are smaller learning units. These learning units facilitate to retrieve, share and reuse. In addition, it helps to define the different learning strategies of Intelligent Tutoring System in order to enhance the performance of system. The proposed ontology is applied in the semantic search engine in order to measure the performance. The retrieval results reveal that the semantic search engine using the SQL learning object ontology achieves with approximately 90% of F-measure in every type of keywords that are one keyword, two keywords and multi-keywords.**

***Index Terms*—SQL, learning object, ontology, intelligent tutoring system.**

I. Introduction

Today, an environmental organization of the online learning is not just only converting media into an electronic form, but it also need to consider on the different learning ability of each learner. The learning ability depends on many factors of the learner such as learner's prior knowledge, learner preference, learner performance, learner's learning style, etc. The learning environment should be designed under the differences of the individual that cause learning with their full potential [1]-[4]. The current online learning (i.e., e-Learning, Web-based Education, Intelligent Tutoring System, Computer Based Training, etc.) focused on the development with regard to adapting to the learner. The Intelligent Tutoring System (ITS) is designed based on learning environment that can adapt itself to the learning characteristics, learner's prior knowledge and learning ability of each learner. It's using a computer that contains the knowledge base for managing the contents and teaching strategies [5]. The ITS is suitable for the learners because it offers the learning contents with a wide range of learning styles. It is operated by the collaboration of several working modules in the system. The first module, called Knowledge-based module, serves to collect all of the learning materials and the learning tests. It has a flexible structure for collecting the contents underlying the knowledge domain, which has two main parts: 1) Knowledge Organization and 2) Knowledge Repository. The second module, called Learner module, will store information about the learners which are performance, learning history and learning styles. Next, Pedagogical module aims to provide an appropriate learning material for each learner using the gathered information. Finally, the result of tutoring system is presented to learners in the Graphical User Interface (GUI) module.

This research focuses on knowledge base organization in the part of Knowledge-based module of ITS. The knowledge domain is the contents of Structured Query Language (SQL). The SQL contents comprise many independent sub-contents and have a variety of formats (e.g., text, images, animation, video, or audio files). Learning Object (LO) is applied for organizing the structure of these sub-contents in accordance with a variety of the learner's characteristics [6]. Each unit of LO has the self-contained and independent content as well as they can link together to be the new one with larger size. Moreover, these learning objects can be selected to merge with the learning management in a variety of learning styles [7], [8]. LOs must have been designed and developed as SCORM [9] and LOM [10]. In addition, this study investigates the LOs based on the context of the web-based learning (that can communicate and access to the system via the Internet). They are implemented by using a semantic web method, which can help to improve the performance of the tutoring system.

The semantic web method has an ability of smart search for selecting and allocating the appropriate LOs according to the learner's characteristics. It is related to three technologies such as XML, RDF and Ontology. These technologies play a key role in deploying and reusing of LOs on the semantic web. They are also used to describe metadata and other information related to the LO with more flexibility and facilitate to search and exchange LOs. Ontology technology will provide concepts of LO on the defined knowledge domain in order to get the required LOs on the knowledge domain [11]. That is the main basis of knowledge base construction. These concepts are arranged in a hierarchical inheritance relationship and they have the specific properties in each concept, which can be used to organize the structure of the LOs. The advantages of ontology are to support reusability and knowledge sharing [12].

This paper presents a design of LO Ontology for the SQL contents according to the ACM / IEEE Computer Society 2013 framework with a combination between the SCORM and Ontology technology. The design will be given an outline of SQL learning object Ontology that can be used to collect and store the knowledge base in the Knowledge Repository. It leads to the personalized creating process in

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order to manage learning materials for the development of ITS that supports the difference learning ability of learners.

II. Related work

Background knowledge related to the design of SQL learning object ontology of the intelligent tutoring system consists of the concepts and components of ITS, LOs, SQL and Ontology as follows.

A. Intelligent Tutoring System

The tutoring will be the most effective, if the students are enable to learn with an instructor who specializes with the guidelines of the individual. Therefore, the ITS should provide the learning materials that are suitable for each individual [13]. Basically, the ITS consists of four standard modules: Knowledge-based module, Learner module, Pedagogical module and Interface module [14], [15]. The functions of each module are:

1) The knowledge-based module will integrate the knowledge base by artificial intelligence techniques in response to the behavior of a learner in a real-time. It uses the knowledge base to create appropriate contents, knowledge assessment, learning state and the requirement of learning styles for the learner according to the learning purposes. The knowledge-based module can also lead to sharing the learning materials. It has two main parts: 1) Knowledge Organization is the management of knowledge base underlying the defined knowledge domain; and 2) Knowledge Repository is a collection of the learning materials and the learning tests for the learners.
2) The learner module will work together with the knowledge-based module to model the learners at that time. This module acts to store information (derived from the learner's activities on the system such as learning ability, learning performance, learning progress, learning styles, learning history, testing history, etc.) and provide the information to the pedagogical module for the decision making on how to create privacy policies for the learner.
3) The pedagogical module acts to manage the learning environment including automatically adapting learning strategies, advising to the learners in their learning, reasoning to provide help to the learners, managing the learning materials, monitoring and evaluating the learning activities of the learners. It is the main module of ITS to communicate with other modules for the adaptive learning management to the learners.
4) The interface module is an interface with users who may be the instructor or the learner of ITS. It provides learning materials, testing results and assessment results for the users [16].

All modules are working together to get the ITS that can response to the learning of learners by the ability of artificial intelligence.

B. Learning Object

The Learning Object (LO) is a small instruction unit as the learning materials. It can convey to learners to understand the taught contents by focusing on the contents that is independent in itself. In addition, it can be combined with the other contents. LOs will be collected, stored, and can be retrieved on demand. It can be reused or referred to support learning technologies [17], [18]. The six major characteristics of the LOs have the following [19].

1) Reusability is the reuse of small objects, which they are the components of the LOs.
2) Shareability is the ability to share and use LOs from the different system to work together.
3) Interoperability is the ability to access and use Los. Even if learners use the different tools such as a computer or a phone, they must be able to access and display the LOs.
4) Self-contained/Integrity consists of the objectives, contents, exercises, or tests of the complete LOs.
5) Conductive to learning is the requirement of the design and development of LOs that can encourage learning and apply in real life.

The designed LOs must be given more details according to the requirements of the SCORM standard to achieve the learning quality and to get the same standard. The more details of LOs describe various properties of the LOs in forms of metadata. These properties are intended to apply for: 1) grouping and searching of LOs; 2) tracking of the characteristic ownership and the management rights of LOs; and 3) communicating with the LMS to provide the LOs to work across different platforms and different system management tools.

C. Structure Query Language (SQL)

The SQL is a special purposes programming language that is designed for managing data in the Relational Database Management System (RDBMS). It was constructed based on relational algebra and tuple relational calculus [20]. SQL contents are important for learning and teaching in all disciplines of computer courses. There are frameworks and priorities of SQL content management that should be adhered to organize the subjects in a curriculum in order to conform to the curriculum of computer science of the Association for Computing Machinery (ACM). In 2013, ACM was defined the SQL contents in the knowledge area of the Information Management (IM). The essence of the SQL contents is "data definition, query formulation, update sublanguage, constraints and integrity". The expectation of learning outcomes of learners is "Creating a relational database schema in SQL that incorporates key, entity integrity, referential integrity and constraints, Demonstrating a data definition in SQL and Retrieving information from a database using the SQL SELECT statement" [21].

D. Ontology

The Ontology is a structure of the concepts that describe the knowledge domain. It consists of the definitions or concepts of the relationship of knowledge structures in forms of a hierarchical data structure to describe the interested knowledge domain. The use of ontology is suitable for knowledge sharing in the same knowledge domain or under the same system. Thus, applying the principles of ontology for designing LOs would be useful for providing the knowledge and building up a standardization of the knowledge contents that transfer to the learners as well. The Ontology Web Language (OWL) is used to represent the ontology to make computers understand the meaning of the information that is developed based on the RDF (Resource Description Framework) [22]. Then the SPARQL (SPARQL Protocol and RDF Query Language) is applied to query the information in a RDF format [23].

In addition, the research studies related to the development of LOs, found that the ontology can be used to represent the knowledge in the development of LOs and able to support the semantic web development. Thus, the ontology plays an important role in creating standards for accessing to the contents and helpful for the learning management [24]-[26]. Moreover, the ontology is applied for constructing the personalized learning contents. The ontology approach can present the LOs, content structures and learning path that are corresponding to the learning environment of each individual [1]. It can also dynamically generate personalized hypertext relations powered by reasoning mechanisms over distributed RDF annotations [4].

All of these related works and theories aim to find solutions to develop a tutoring system that can adapt to learners to achieve an appropriate and effective learning.

III. Development Process

In the design of SQL learning object ontology for ITS, this paper proposes a working model that is based on the ADDIE model [27] in the development of LOs and Ontology Life Cycle [28]. The process is shown in Fig. 1.

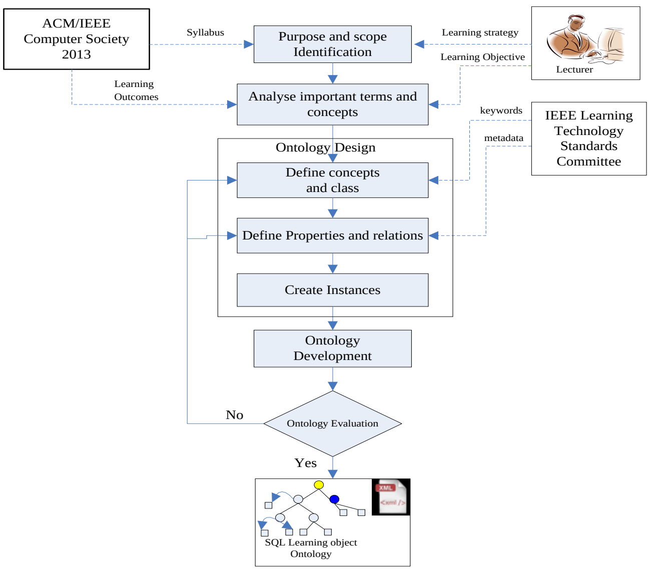


Fig. 1. SQL learning object ontology development process.

The details of the process are the following:

A. Purpose and Scope Identification

The purpose of the design and development of the SQL learning object ontology is used to create a knowledge base of SQL contents for the intelligent tutoring system. The knowledge domain is based on the computer science curriculum framework of the ACM/IEEE Computer Society 2013 including learning strategies and learning objectives from the instructors. The SQL knowledge domain for the design of the ontology is shown in Fig. 2.

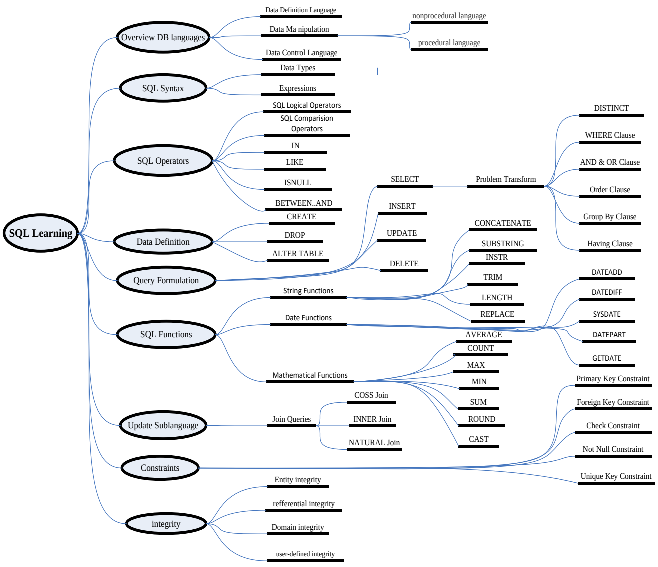


Fig. 2. SQL knowledge domain.

B. Analyze Important Terms and Concepts

The analysis of main concepts to design the SQL learning object ontology is obtained from the learning outcomes (provided by the computer science curriculum framework, 2013), learning objectives from the instructors (provided by the course of the academy) and the SCROM of learning object in accordance with the defined SQL knowledge domain. The analysis found that the knowledge representation should present the SQL contents in forms of concepts, assignments, examples as well as descriptions.

C. Ontology Design

The design processes of the SQL learning object ontology are the following:

1) Define concepts and class

The SQL concepts are defined and divided into 4 main classes which are CourseDomain, LearningMaterial, AssessmentMaterial and ContentDescription. Each class contains subclasses as follows:

- CourseDomain class: a class about the details of all the contents. It is divided by the principle of learning objects. There are 3 subclasses: ContentUnit, ContentObject and ContentAsset.
- ContentMaterial class: a class of learning resources to practice and apply the SQL commands. There are 2 subclasses: Example and Assignment.
- AssessmentMaterial class: a class about the learner assessments of either learning content. There are 2 subclasses: Quiz and Exercise.
- ContentDescription class: a class to represent the learning object information, i.e., objectives, expected learning outcomes, names, priorities (optional / must take), prerequisite, keywords, contributor, etc.

The class hierarchy of SQL learning object ontology is shown in Fig. 3.

2) Define properties and relations

The next process is to define the properties of classes and the relations between classes including the learning object metadata inside the knowledge domain. For examples of the properties and relations:

- The relation "is-a" such as Exam is-a ContentMaterial and Quiz is-a AssessmentMaterial.
- The property relation "part-of" such as ContentMaterial part-of ContentUnit and AssessmentMaterial part-of ContentUnit.

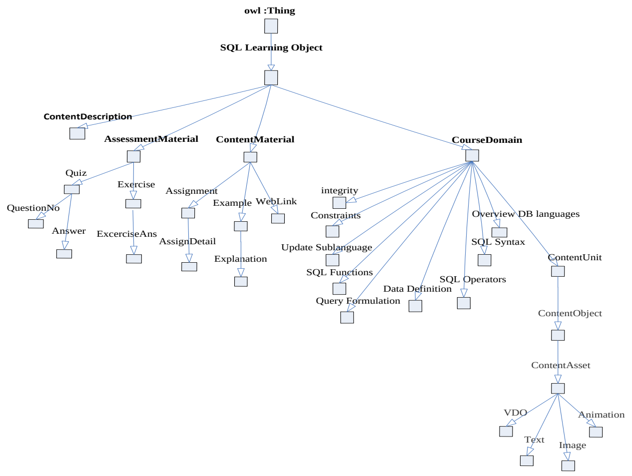


Fig. 3. SQL learning object hierarchy.

The schema of the ontology is shown in Fig. 4.

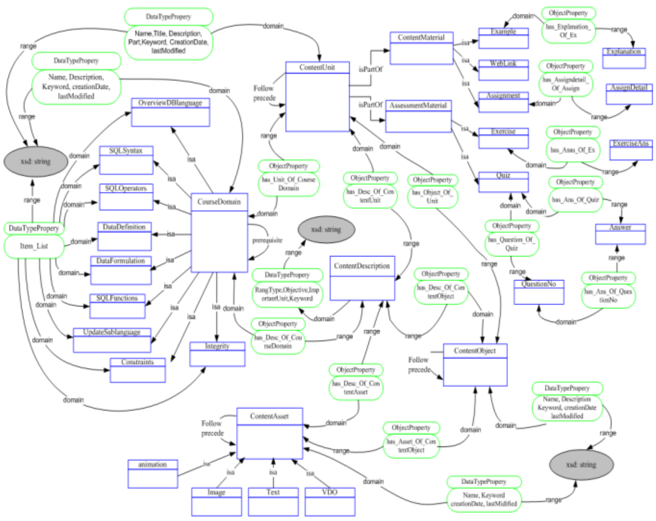


Fig. 4. SQL learning object ontology.

3) *Create instances*

The instances will be defined in each class. For example, the SELECT Statement is an instance of the ContentAsset, the SUBSTRING() is an instance of the SQL Functions, the www.sqlcourse.com is an instance of the WebLink, etc.

IV. Ontology Development

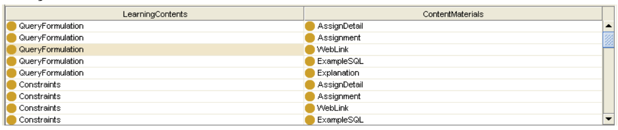
After the ontology has been designed, the knowledge base of the SQL learning object ontology is created using a tool called the Protégé [29]. The knowledge is stored in the forms of Ontology Web Language (OWL) that describes an ontology structure based on the semantic web. A hierarchical structure and a relationship of ontology are based on RDF as depicted in Fig. 5.

```
 xmlns:swrlb="http://www.w3.org/2003/11/swrlb#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:owl="http://www.w3.org/2002/07/owl#">
<owl:Ontology rdf:about=""/>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#AlterTable">
    <rdfs:subClassOf rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#DataDefinition
</owl:Class>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#ConceptDomain"/>
<owl:ObjectProperty rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#ConceptDoOfEx">
    <rdfs:domain rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#SQLOperators"/>
    <rdfs:range rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#Example"/>
</owl:ObjectProperty>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#Constraints">
    <rdfs:subClassOf rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#ConceptDomain"
</owl:Class>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#Contentinfo"/>
<owl:ObjectProperty rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#ContentInfoOfOverv
    <rdfs:domain rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#OverviewOfDatabase
    <rdfs:range rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#Contentinfo"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#ContentInfoOfSQLSy
    <rdfs:domain rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#DataType"/>
    <rdfs:range rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#Contentinfo"/>
</owl:ObjectProperty>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#Create">
    <rdfs:subClassOf rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#DataDefinition
</owl:Class>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#DataControl">
    <rdfs:subClassOf rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#OverviewOfData
</owl:Class>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#DataDefinition">
    <rdfs:subClassOf rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#ConceptDomain"
</owl:Class>
<owl:Class rdf:about="http://www.owl-ontologies.com/Ontology1355313523.owl#Datadefinition">
    <rdfs:subClassOf rdf:resource="http://www.owl-ontologies.com/Ontology1355313523.owl#OverviewOfData
```

Fig. 5. OWL formats of SQL learning object ontology.

To retrieve the knowledge stored in the OWL formats, the special-purpose language, called SPARQL, is applied. The example of SPARQL query language with 2 query keywords: LearningContent and ContentMaterial are revealed in Fig. 6.

SELECT ?LearningContents ?ContentMaterials
WHERE {
?LearningContents
rdfs:subClassOf :CourseDomain. ?ContentMaterials
rdfs:subClassOf :ContentMaterial .
}



LearningContents	ContentMaterials
QueryFormulation	AssignDetail
QueryFormulation	Assignment
QueryFormulation	WebLink
QueryFormulation	ExampleSQL
QueryFormulation	Explanation
Constraints	AssignDetail
Constraints	Assignment
Constraints	WebLink
Constraints	ExampleSQL

Fig. 6. Query results by SPARQL.

V. Ontology Evaluation

There are several approaches to evaluate the ontology. The most popular approach is to apply it in a semantic search to test an accuracy of retrieval. The experimental environment of this paper uses 10 users to test the accuracy of retrieval using 3 types of keywords that are 1 keyword, 2 keywords and multi-keywords. The results of retrieval are depended on the different requirement of each user. Therefore the accuracy of retrieval of the proposed semantic search engine is compared with the results defined by these users. In this research, the accuracy is measured using precision, recall and F-measure as the following equations.

Precision = (Number of accurate results*100)/Total of answers retrieving by the system

Recall = (Number of accurate results*100)/Total of accurate results from raw data

F-measure = (2 $\times$ Precision $\times$ Recall)/(Precision + Recall)

where *F*-measure is the equally weighted harmonic mean of precision and recall.

The experimental results reveal that the users can get the information as their requirements at approximately 90% of F-measure in every type of keywords.

VI. Conclusion and Future Works

This paper presents the design of the learning object ontology for SQL contents according to the computer science curriculum standard of the ACM / IEEE Computer Society 2013 by using the SCORM and the Ontology approach. The designed ontology schema can be used to collect and store the knowledge base of the small learning units and the relations between such units in the knowledge repository. The small learning units of the SQL learning object ontology facilitates to retrieve, share and reuse. Moreover, it helps to define the different learning strategies of the ITS for suggesting the different learning path of each individual. The ontology is applied in the semantic search engine in order to measure the performance. The retrieval results reveal that the semantic search engine achieves with approximately 90% of F-measure in every type of keyword. In the other words, the future work is the development of SQL knowledge base of the ITS that can support the personalization of the learners and improve the performance of the ITS.

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