Study on Construction of University Course Ontology: Content, Method and Process

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***Abstract*—To solve the problem of lacking of Ontology content in the Semantic World Wide Web, this Paper proposed that the University should be responsible for the initial construction of Domain Ontology, which in the form of Course Ontology. Then the upper layer contents and structure of course Ontology, the construction method and the construction process were deeply explored, and a easy way to implement course Ontology was proposed for non-professional users who don't have too much knowledge of computer, which made it possible for the scholar from every field to participate in the construction of Ontology. Thus the bottom structure could be provided to implement semantic world wide web.**

Keywords-Course Ontology, Ontology Content, Method, Process, Tools

I. INTRODUCTION

With the deep study on Semantic Web technology, researchers in education domain predicted a prospective future of the semantic web technology which could used in education field. Researchers predicted that the ultimate realization of the Semantic Web and its application in education will completely change the current education mode.It will lead to a revolution of education mode[1]. The prerequisite of Educational Semantic Web is that there is a large number of Ontology available in the Internet which can be used to describe the content of education. While the prerequisite of Ontology description of education content is that related ontology should be constructed. With the explosion of knowledge today, it is important to decide who will be responsible to create such large number of domain Ontology? How to create it? How to evolve it? ... ... A lot of problems which are related to Ontology creation and management need to be solved. Although the researchers have proposed a variety of Ontology creation methods, most of them focused on the development of some special Ontology[2]. The author believed that as the creators, disseminators and users of knowledge of advanced Science and Technology, the University should be responsible for the creation of domain Ontology. In this article, the author proposed an Ontology creation methods which facilitate the students and professors in the University to cooperate to create domain Ontology which is inside related subject field. This article has referred to the related ontology development methods which are available at present and also referred to IEEE1074-1995 standard. The method is based on the characteristic that university knowledge is organized as the form of the course. The author has an intention to implement and popularize the method gradually in the university through of teaching a course named "Knowledge Engineering and Ontology" in the university.

For this purpose, the following five topics will be discussed: related research on construction of curriculum or course Ontology; research on the environment and feasibility of construction of university course Ontology; analysis of development requirement of university course ontology; research on design and implementation method of university course ontology; research on management and maintenance of university course Ontology.

II. RELATED RESEARCH

Just as the same as ontology, course ontology have both the explanation which has philosophy meaning and the explanation which is used in the computer application field. From a point view of philosophy, courses Ontology studies curriculum courses' "being", which is to explore and think the theories of why the "presence" of courses as "being"[3]. From the field of computer applications, course Ontology is used to express the concepts and the relationships among those concepts, either in a course[4][5][6] or in a series of related courses[7]. The study of course Ontology in the computer application field covers 3 aspects: the content and composition of course Ontology, the methods of course Ontology creation, as well as the research on the education application system which is based on course ontology. The below part describes in brief about these 3 aspects.

A. Related Research on the Content and Composition of Courses Ontology

There is no doubt that the basic components of courses Ontology are the concepts and their relationship. Different courses have different concepts, so many courses Ontology relevant researches focused on the organization of concepts in the course[4][5][7]. Some researchers wanted to proposed a generalized expression of construction of courses Ontology, which led to the construction of upper level courses Ontology. Among them, Corvinno technology divided a top-layer course Ontology into five categories, which are named as Curriculum,

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Knowledge Area, Basic Concept, Theorem, and Example [8]; NETg divided course ontology into 3 layer structure, which are named as Unit, Lesson, and Topic[9].

During the process of instructing teachers to construct course ontology, some researchers found that it's easy for the teachers to identify the concepts in a course, but it's difficult for them to make explicit expression of their relationship. For this reason, the researchers proposed to establish five kinds of basic conception relationship of course Ontology. The 5 kinds of relationships are 'superclass-subclass', 'class-instance', 'super-sub', 'relevant to', 'mentioned by', as well as the possible expansion of these relationship[10]. Some researchers divided the relationship types into such ones as 'Is-a', 'HasSubtype', 'HasPart', 'IsBasisOf', 'HasConstraint', 'HasFunction', 'HasDefinition', 'HasSynonym', 'HasAsExample', and 'HasFurtherExplanation'[11]. Corvinno technology divided the top-level courses Ontology into such ones as 'element of', 'belong to', 'part of', 'requires knowledge of', 'refers to', 'premise', and 'conclusion', etc.[8].

This article has referred to the achievement which is about the relationship of top-level Ontology and course Ontology. The top-level ontology and their relationship is specified in the development of course ontology so that course Ontology developer could develop course Ontology according to the same content structure.

B. *Related Research on the Methods of Course Ontology Creation*

Course teachers are usually considered as the appropriate ontology creators, some researchers provided ontology construction method which is suitable for course teachers.

Boyce and Pahl provided an easy way for domain expert to develope Course Ontology which includes 5 steps[11]: The first step, using textbooks to identify key concepts in the course content. The second step, using top-down approach to organize concepts. The third step, using entity-relationship (ER) diagram to express Ontology. The fourth step, using concepts and their relationship to define the Ontology. Finally, using concepts and content to classify Ontology. Among them, the use of ER diagram to express the concepts and their relationship is a simple method to help the domain experts to present course Ontology model. With few training, the domain expert could start to construct domain Ontology of course. After the success of the model presentation, the Ontology engineer can use a facilitated Ontology editing tools to further transfer the model into the Ontology and get the ontology file.

Ming-Che Lee and his fellows proposed a ontology creating method named "purpose-oriented model", which includes: (1) Define the domain and purpose of the target Ontology; (2)Consider reusing available Ontology; (3) Survey important terms in this domain; (4) Define classes and class hierarchy; (5) Define characteristic of classes; (6) Create instances[6].

This paper will propose a unified process for courses Ontology creation, by adding process of feasibility analysis, Ontology maintenance and management to the above-mentioned methods.

C. *Formal Description Language of Courses Ontology and It's Editing Tools*

Protege and TM4L are commonly used tools for education Ontology creation, RDF / OWL and XTM are 2 languages respectively for describing information semantics. OWL is an expansion of RDF vocabulary. The key elements of an OWL Ontology include 'class', 'property', 'instance', and the relationship between these instances (OWL Guide). In TM4L, the main components which is operated by XTM are 'Topics', 'relationships', 'resources' and 'views'. XTM Topics cover the OWL classes, characteristic, and instances. The relationship of XTM is quite similar to that of OWL. The resources of both XTM and OWL could be expressed by URI. All elements in XTM can be expressed in OWL, but some of the characteristic of OWL can't be expressed in XTM Language. Therefore, it is needed to use the tool to convert XTM file to OWL/RDF file [12].

At present the ontology creation especially the OWL ontology which performs as the base of semantic network technology is created by Protégé. Protégé is wildly used as the Ontology editing tool[13][14][6][7], but to those domain experts who do not understand Ontology-related concept will find it difficult to use protégé. Therefore, based on the more easily understand concepts of Topic Map, some researchers developed TM4L to be used as educational Ontology creating tools[15]. This editing tool is the unique general education topic editor and displayer which could be used free of charge. A lot of researches use TM4L as ontology editing tool to create education course ontology[16][17][18][19]. In addition, the version 2.0 of TM4L provided the conversion between XTM and RDF documents.

This article selects TM4L as the tool of ontology implementation. During the stage of Ontology verification and management, we will convert the XTM files to RDF files, and store both XTM files and RDF files. At the stage of Ontology analysis and design, we recommend to use the ER diagram so that it could be used by a wider range of people to communicate and share.

III. Analysis of Environment and Feasibility of Courses Ontology Development

One of the functions of universities is to create and disseminate knowledge[20]. Modern technology, especially Internet technologies enable the University to the disseminate knowledge to every corner of the world. After MIT's Open CourseWare movement (OCW), many famous universities opened their courseware in the Internet[21]. This is the way the University demonstrate their social responsibility of dissemination of knowledge. With the development of semantic web technology, a completely new mode of education is foreseen[22]. It could completely overcome the disadvantages of current education mode. The success of the Semantic Web lies on the existence of a large number of Ontology, so the universities should be responsibility for the creation of domain Ontology to support educational semantic web. The knowledge of university is often organized by the form of a course, so it's easy for university to provide course Ontology.

Just like that domain experts are involved in the construction of knowledge base. University teachers have a comprehensive and in-depth understanding of the course, so in the process of course Ontology construction, university teachers should act as domain experts to verify the accuracy of course concepts and their relationship.

As a course learner, university student should be the final implementer of the course Ontology construction. And the university students could deepen their understanding of the course after analysis, design and implementation of the course Ontology.

IV. REQUIREMENTS ANALYSIS OF ONTOLOGY DEVELOPMENT OF UNIVERSITY COURSES

The first goal of building a course Ontology is to provide domain Ontology for semantic web so that the semantic web has a knowledge base. Therefore, the university course Ontology should be able to describe the concepts, theories and the relationship of a course. For an Ontology construction in a specific knowledge domain, you could refer to the available domain knowledge vocabulary which is used in current library system and reuse the vocabulary to create the base of domain knowledge ontology.

Secondly, a curriculum may involve a number of fields of knowledge. The knowledge of these fields interconnects with each other through the teaching goal. So the course Ontology should describe the relationship between different field of knowledge, not just merely construct ontology in a specific knowledge field.

Finally, the destination of university course Ontology is to provide a set of basic resources for the Semantic Web, to achieve the idealism on education semantic web, which includes recommendation of personalized learning resource which is based on ontology[23], and also the creation of personalized adaptive learning spaces[24]. Therefore, the Ontology of university courses should be able to describe in detail about the learning objectives, which includes career goals, knowledge goals, motion skill objectives, emotional objectives. Thus, the upper layer of university courses and the relationship between those concepts is described in below diagram:

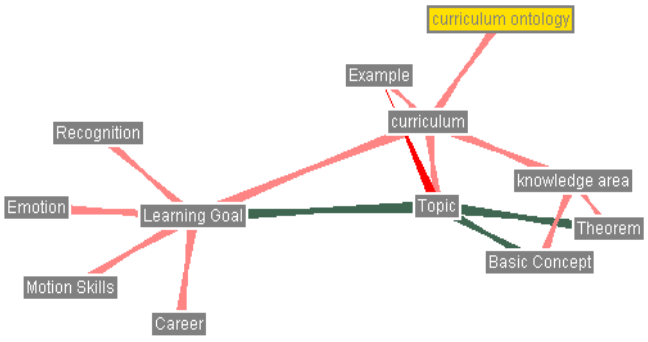

Figure 1. course Ontology and their relationship

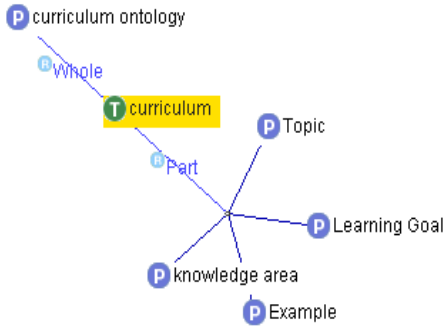

Figure 2. the relationship between courses

Figure 3. relationship related topic

Among them, Curriculum, Topic, Knowledge Area, Basic Concept and Theorem composed of the abstract top-level of Ontology. The relationship among Curriculum and Topic, Knowledge Area, Example belongs to "whole-part" relationship. The relationship between Topic and Example belongs to "instance " relationship. The relationship among Topic and Basic Concept, Theorem, Learning goal belongs to "Related-Topic" relationship.

Development of every specific course ontology should be base on the top-level relationship and general relationship which are described above. The individual course Ontology could be created by adding subclasses, subcharacteristic, and instance of classes to the top-level Ontology.

V. THE PROCESS AND METHOD OF THE DEVELOPMENT OF UNIVERSITY COURSES ONTOLOGY

This article proposed that the development of university course Ontology should be implemented by the students, who have a certain knowledge of the course and a deeper understanding of Ontology engineering, Ontology related concepts and Ontology tools. The university teacher should review the Ontology design to guarantee its accuracy. We call them course expert here. In addition, the personnel who manage ontology resources should audit, handle and publish the Ontology which is provided by ontology implementer. The specific process is described in below part:

First of all, the Ontology implementer inquires course expert about the suitable textbook or other reference material to identify all the concepts.

Secondly, all concepts are organized by catalogue according to the top-level Ontology classification, and the ER diagram should be used to express concepts and their relationship which have been catalogued to make it clear, easy to be understood and with no confusion. In this way it could facilitate the domain experts such as university teacher to understand and review the design of Ontology.

Thirdly, after ontology design has passed the review of course expert, the Ontology realizer use the Ontology editing tools TM4L or Protégé to construct ontology.

Finally, the finished course Ontology was submitted to the Ontology management center of the university. After the personnel of management center has reviewed the Ontology, the XTM file is converted to the OWL file, or OWL file is converted to XTM file. Two kinds of files will both be published in the ontology resource database of the university so that they could be used in the Internet.

VI. CONCLUSIONS AND SUGGESTIONS

When ontology construction method and process as well as top-level abstract Ontology frame have been determined, Ontology creation by man-power won't be a job with high technology and high difficulty which needs deep comprehension of computer background knowledge, Discrete Mathmetic knowledge, Artificial Intelligent knowledge and etc. For the teachers and students who have mastered a course knowledge, ontology construction is a time-costing and energy-costing job which need some basic method and tool using skill.

It becomes possible for the students and teacher to create the course Ontology by themselves.

The author suggests that a public elective course named "knowledge engineering and Ontology" should be offered in the universities. After the students studying in this course, they could master the method of ontology construction. If most of the university students and teachers take part in the creation of domain Ontology, we will have enough Ontology to implement the educational semantic web.

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