Indonesian Journal of Electrical Engineering and Computer Science
Vol. 24, No. 1, October 2021, pp. 507~518
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v24.i1.pp507-518

Development of ontology-based model to support learning process in LMS

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Article Info

Article history:

Received Jul 25, 2020
Revised Jul 13, 2021
Accepted Jul 28, 2021

Keywords:

Course ontology model
E-learning
E-tutor
Learning process
Ontology of e-learning
Pedagogy

ABSTRACT

E-Learning is an important support mechanism for educational systems to increase the efficiency of the education process including students and teachers. The current e-learning systems typically lack the level of metacognitive awareness, adaptive tutoring, and time management skills and have not always met the expectations of the learners as required. In this study, we introduce a novel ontological model for the learning process in the e-learning domain. In the framework, we have built a domain ontology that represents knowledge of the learning, the outcome domain ontology covers the whole learning process. We focused on the learning process ontology model conceptualizing knowledge constructions, such as learning courses, and we present the created course and learning process ontology in detail. In this work, we considered three layers of learning process. The top layer defines a general framework of learning process, conceptual model layer, defines the framework of the actual process of the learning process and course ontology model contains the knowledge unit of the learning process. The prototype ontology is constructed in protégé and managed by Java web ontology language-application programming interface (OWL-API). As a result, our model can solve the problems of current e-tutor systems. Also, it can be used for different domain in e-tutor systems. It can reach the characteristics of standardization, reusability, flexibility, and open knowledge. By applying this model, we can avoid applying isolated databases. The constructed ontology can be used in the future to control adaptive intelligent e-tutor frameworks.

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1. INTRODUCTION

Although great technologies like ontology arising to increase the efficiency level of e-learning models. Ontology can play a significant aspect in semantic web technology and can change the whole field of e-learning. There are different definitions in the literature for ontology the most common defined by Gruber's ontology is a shared and common understanding of a domain that can be communicated between people and across application systems [1]. Instead of depending solely on individual human specialists, ontologies reflect a formal and consensual common knowledge of the topic of interest as agreed upon by the domain community [2]. The opportunities that arise as a result of the availability of domain ontologies have an influence on the development of e-learning. Ontology is a tool that is applied to control the workflow in the

e-learning management systems. The domain ontology also gives a mechanism for formal specification and validation of e-learning to be communicated across people and applications.

The e-learning society is trying at having greatly more powerful services than what are currently given by any of the possible computer-aided tutoring, or learning management systems. The trend of information and communication technologies (ICT) called semantic web technology has the possibility to be implemented in many areas. E-learning is one of the domains which may benefit from this innovative ICT. The development of ICT allows "anywhere-anytime" teaching and learning communications, which we name electronic learning (e-learning). E-learning requires self-learning habits as well as individual motivation to learn. E-learning does not only ensure the easy availability of learning resources everywhere, via a repository of learning resources, it also promotes features such as personal definition of learning goals, synchronous and asynchronous communication and collaboration between learners and learners and instructors [3]. E-learning is a way to perform teaching and learning using computer and internet technologies. E-learning is a process in which the electronic medium is used to access the defined set of applications and processes. This indicates that the development of e-learning courses involves a lot of experts from many fields collaborating together including instructional design, multimedia, graphics and the subject material. Therefore, there may be a substantial impact on the development of e-learning courses due to a knowledge gap among participants.

New technologies such as ontologies are now available to enhance e-learning models' efficiency. The ontology term has been used extensively in the domains of intelligence, computer and information enterprise in recent years, especially in areas such as information systems, collaborative, intelligent information integration and information retrieval and extraction, knowledge representation, and database management systems. And implies many different definitions of the term. Ontologies can be used as a framework for defining formal education and training at universities and education courses in blended e-learning (one-to-one interaction) and for recognizing services. Must be on the ontology of e-learning, involving classification of educational institutions (providers of course), and courses, and the people required in the process of teaching and learning. Ontology may play an essential role in semantic web technologies and ontology can without any doubt impact the entire area of e-learning [4]. According to Gruber's definition [1] of ontology, ontologies represent a formal and consensual shared knowledge of the domain of interest as agreed upon by the domain community instead of depending solely on individual human experts. The opportunities emerging from the availability of domain ontologies have an influence on creating e-learning courses. Our research is concerned with developing of a general e-learning course ontology, this e-course domain ontology might be utilized among others as a basis for building adaptive e-learning courses and to evaluate the efficiency of the training processes. The proposed ontology model involves, e-course domain ontology concepts, module descriptions, learning objectives, learning objects, teaching methods, learning assessments and learning media. In e-learning management systems, ontology may be used to oversee the workflow in these systems. The e-course domain ontology also offers a mechanism to formally specify and validate e-learning course terms that may be conveyed to individuals and applications.

Most e-learning systems developed for a specific domain means the solution of one knowledge domain can't be suitable for the other knowledge domain. These systems that developed for isolated databases have some limitations. Lack of reusability and standardization, limited knowledge, lack of flexibility, and manual control are some drawbacks to using local databases. Due to this problem, we propose an ontology domain model to avoid the problem of local databases. To promote the learning process, the contribution of this paper we developed a novel ontology model to define a set of relationships that would be adequate and clear to represent all possible relationships for building the ontology model. The proposed ontology model is a general framework the goal is to find the behavior of students, cover the total learning processes (LPs) and their components. The proposed model involves three layers of LPs, first the top layer architecture, second conceptual layer architecture, and third the course ontology model architecture. in this work we are going to explain these layers in detail.

The paper is organized: the introduction and th methodology of designing the ontology int the first section. In the second section show the related work and definitions of some terminologies, the third section defines the proposed ontology model and we explain our proposal model of learning process in details, in the fourth section we present some case studies on ontology implementation using Protégé and the ontology evaluation process, in the fifth section show the result and discussion, and the conclusion in the sixth section.

- Methodology of ontology design

The design and development of ontology usually encompasses several tasks. There is no one standard methodology for developing ontologies. The main rule is the ontology concepts to be close to the objects and the relations in the given domain. The methodology for creating an ontology assumes defining the objectives and domain of applicability. Therefore, it has to be identified in advance: what is the goal of designing this ontology, what types of questions should be answered through it, how it will be used and

supported. There are several methods for ontology development such as [4]-[6]. Though these methods are somewhat varied and are impacted in certain ways by the instruments used, the overall process of ontology development is the same. Therefore, the suggested ontology development process is comprised of the following stages,

- Domain and purpose of the ontology
- Discover if there are related ontologies
- Enumerate important terms in the domain
- Defining the classes and the class hierarchy
- Describe the properties of classes
- Attaching facets to properties
- Creating class instances

2. RELATED WORK

2.1. E-learning

The concept of e-learning has evolved dramatically over the past 40 year's decade. From simple online text to intelligent e-learning, regarding to the fast development of the technology's capabilities, on the software and hardware [7]. Although there are many definitions of e-Learning, but generally, all of them focus on the same key features. E-learning framework as a computer based educational tool or system that enables you to learn anywhere and at any time [8]. Computer and Internet technologies can be used in e-learning systems to deliver a broad array of solutions to enable learning and improve performance [9]. The field of e-learning encompasses a broad variety of applications, extending from virtual classrooms to remote courses or distance learning [10]. Learning management systems (LMSs) can be defined as web-based systems that enable teachers and students to share materials, to submit and return assignments and to communicate online [11]. LMS is the most widely used software to plan, implement and evaluate specific learning processes [12]. Web-based educational systems (WBESs) can offer interesting novel delivery mechanisms to teachers and learners to increase efficiency [13]. E-learning management electronic system (EMES), also called content management system, is computer software that enables users to create, edit, collaborate on, publish and store digital content [14]. EMES helps users create, manage, and modify content on a website without the need for specialized technical knowledge. In more straightforward language, EMES is a tool that helps us to build a website without needing any experience [15]. EMES is an application used to manage the learning content, allowing multiple contributors to create, edit and publish the content. EMES has the features of content creation (will make it possible for users to create and format content smoothly), content storage (stores content in a single location consistently), workflow management (grants privileges and responsibilities according to roles such as authors, editors and administrators), and publishing (plans, arranges, and pushes content live) [16]. EMES is a software application that allows publishing, editing and modifying content and maintenance from a central interface. In addition, such systems of learning management provide procedures to manage workflow in a collaborative environment [16].

E-tutor system, it is also called as the online tutor or e-moderator, is intended to facilitate student activities. In many online classrooms, the e-tutor will be an individual different from the teacher in charge [17]. Intelligent tutoring system (ITS) is a computer system designed to support and improve the learning and teaching process in the domain of knowledge [18]. ITS is a computer science and cognitive science to create computerized tutoring systems that offer immediate feedback and individualized instruction [3]. Smart tutoring (ST) is a web-based intelligent tutoring system designed to adapt teaching tactics and student models that rely on background knowledge and skills, and teaching techniques convenient to certain skill sets and the cognitive model of instructors guides them to bring back their previous teaching experiences through selecting one or more of them that are closer to the ongoing situation and adopt them for reuse [19].

2.2. Pedagogy

Pedagogy is the art or science of teaching and educational methods [20]. Pedagogy can refer specifically to the function of a teacher (teaching) and the teaching methods/theories being employed [20]. Pedagogy is the dynamic relationship between learning, teaching and culture. The classroom activities of instructors, in terms of learning and teaching, are supported by their concepts and beliefs on education [21]. Pedagogy interacts with, combines views and draws beliefs about learners and learning, teacher and teaching, and curriculum [22]. There are many tools supporting pedagogy, e-learning tools can support pedagogies to achieve the following goals [23]:

- Effective pedagogies adjusted to behavior, knowledge and understanding.
- Effective pedagogies involving clear thinking about learning outcomes and goals.
- Effective pedagogies built on students' prior learning and experience.

- Effective pedagogies to improve the efficiency of student learning.
- Effective pedagogies involving a variety of approaches, including whole-class and structured group work, supervised learning and individual activity.
- Effective pedagogies focusing on developing higher order thinking and metacognition, and make good use of dialogue and questioning in order to do so.
- Effective pedagogies embedding assessment methods for learning.
- Effective pedagogies that are comprehensive and take the various needs of a range of learners.
- Effective pedagogies involving important feedback from students, which can help improve teaching and learning.

In the following we take first a general view about related works on ontology, ontology models for e-learning, general requirements on ontology for e-learning and then we discuss the details of our proposed ontology model.

2.3. Ontology

We can find many definitions of ontology in the literature. Among them the most popular is given by Sunitha and Suresh [24] ontology is an effective technology that enables integration of related resources, sharing the right knowledge and avoids irrelevant information. Ontology is the basic description of things in the world [25]. An ontology is referred to an engineering artifact in the field of information science which consists of a specialized language to define the world. Ontology in computer science can be defined as a formal representation of the knowledge using a set of concepts and relationships between those concepts [26]. Ontology is used both to reason in target domain and to validate the created semantic model [27]. In theory, ontology is a formal, explicit specification of a shared conceptualization [1]. Ontology offers a shared vocabulary, which can be employed to model a domain including the type of objects, related concepts and their properties and relationships. An ontology can be considered as an explicit representation concerning the domain of concepts, properties of concepts, constraints on properties, and individuals. Also, ontology describes a common vocabulary and a shared understanding. The main aspects of building an ontology are to share a general understanding of the construction of knowledge between Humans and the software artifacts, facilitate reuse of the domain knowledge, introduce standards, enable interoperability, create domain assumptions explicit, analyze the domain knowledge, separation of domain knowledge from the operational knowledge, and flexibility [28]. Ontology offers a standard language applied for the construction of the ontology and reasoning. Razmerita [29] investigates ontology languages as a classifying the models according to the applied knowledge representation formalism: enrich first-order predicate languages, frame-based methods, and description logics. The common language for ontology modeling and reasoning is web ontology language (OWL), which is a language built upon description logic. OWL language recommended by the world wide web consortium (W3C) in 2004. W3C defines OWL as a web-based semantic language developed to describe rich and sophisticated knowledge about things, groups of things, and relations between things [24]. OWL is a language built upon computer logic such that knowledge represented in OWL can be utilized by computer programs, e.g., to validate the consistency of that knowledge or to make implicit knowledge explicit. OWL can be considered as a language of knowledge representation for the formulation, exchange, and reasoning of the domain of interest.

2.4. Ontology model for e-learning

Several works on ontology model for e-learning can be found in the literature. Tunde *et al*. [30] proposed ontology-based model for e-learning management system (O-BMEMS) aiming at improving efficiency and relevancy. They presented ontology includes among others course syllabus, teaching methods, learning activities, and learning styles. Srivastava *et al*. [10] proposes new model for e-learning system, using semantic web technology. The model consists of various services and tools, such as: course registration, uploading course documents and student assignments, interactive tutorial, announcements, useful links, assessment, and simple semantic search. The implementation of the model provides to students two kinds of contents, learning content and assessment content. The framework contains different types of services such as: learning services: provide registration, online course, interactive tutorial, course documents, announcements, links, student papers, and semantic search. Chung and Kim [31] introduces an ontology model and proposes an effective method for enhancing the learning effect of students through the construction of subject ontology. The ontology of a particular course is comprised by ontology made by a teacher and many ontologies made by students. This ontology is used in discussions, visual presentations and knowledge sharing between instructor and students. The ontology model was tested by the analysis of students' feedback in two lectures in practice and it was found that the proposed ontology improves the learning efficiency of students significantly. Panagiotopoulos *et al*. [32] proposed an intelligent tutoring system (ITS) where student models are enhanced with semantics extracted from ontology database. There are

two key taxonomies in the associated ontology schema: (a) academic information of the student and (b) personal information of the student. The features of the student model have been determined through an empirical study on various student groups. In order to be able to develop ontology for e-learning processes to provide high-level services for users looking for suitable online learning, one must consider also technical concepts and issues such as a knowledge base implementation, which is the core of the architecture [7].

2.5. The comparison of the proposed model with other in the literature

Table 1 is the comparison of our model according to some criteria or features covered they are (reusability, standardbility, flexibility, open knowledge, simplecity, and reasoning engine shown in Table 1.

Table 1. Comparison of the models

	Reusability	Standardability	Flexibility	Open knowledge	Simplicity	Reasoning engine
Knowledge graph	√	√	×	√	×	√
Semantic network	√	√	×	√	×	√
Rule-based	×	×	×	×	×	√
Case-based	×	×	×	×	×	√
Belief network	×	×	×	×	×	×
Darwin information typing architecture (DITA)	√	√	×	√	×	×
Ontology-based	√	√	√	√	√	√

√ means feature is allowed, and × means feature not allowed.

3. PROPOSED ONTOLOGY MODEL OF LEARNING PROCESS

In order to support the learning process, the authors developed an ontology model to define a set of relationships that would be sufficient and clear to represent all possible relationships for building the ontology model. The proposed ontology model is a general framework, the main goal is to find the behaviour of learners, cover the whole learning processes (LPs) and their components. In this section, we are going to explain the structure of the proposed model which includes three layers of LPs, the top layer architecture, the conceptual layer architecture, and course ontology model architecture.

The ontology-based model enables a description of the learner's properties which contains important information about domain knowledge, learning performance, interests, preference, goals, tasks, and personal characteristics [33]. It will also be useful for cognitive awareness and adaptive learning. It can identify the context of the learner and modify the learning process accordingly [34]. The ability of the learning environment to recognize and adjust the context of the learner plays an important part in personalized learning.

3.1. Top layer architecture

The objective of this layer is to define a general framework of LPs to the learners shown in Figure 1, the framework consists of some objects, which are: The learners who want to learn about a particular subject or how to do something. Interface: should be well-designed so that people (users) interact with the computer simply. It can contain both hardware and software components [35]. Learning media: Learning media forms something that can deliver a message, stimulate thought, feeling and will encourage the learning process. Learning media is a means for channeling learning messages and information. Well-designed learning media will hugely help learners achieve learning objectives [36]. Knowledge unit: means the model of concepts, principles, theories and practices that are related to a course to learn or study. It is described as a theoretical and/or concept knowledge. Presentation unit: is a technique that teachers could use to improve students learning and helping to better regulate their learning through the use of effective learning techniques [37]. Presentation form: refers to the resources that are using in the learning processes, used to assist the students in acquiring knowledge and profiling different abilities and values. Evaluation form: represents the final stage of working with teaching and learning resources. The purpose of evaluation is to evaluate the effectiveness of a particular teaching and learning resource in attaining the goals and objectives of teaching; in other words, its contribution to the processes of understanding, linking and interpreting, developing desirable skills and adopting certain values of students. Model of learning: is to interpret student behaviors and then distinguish students according to motivations, habits, forms, skills and competences [21]. Motivations: refers to the factors that stimulate desire and energy in student to be continually interested and committed to learn, role or subject, or to make an effort to attain a goal. Habits: refers to a usual way of behaving or a tendency that student has settled into, as in "good learning habits". Forms: refers to a supporting frame model of the student figure or part of the student figure that used for learning material. Skills: refers to the ability of students to use one's knowledge effectively and readily in execution or performance in a learning process. Competences: refers to the knowledge that enables a student to learn and understand a subject.

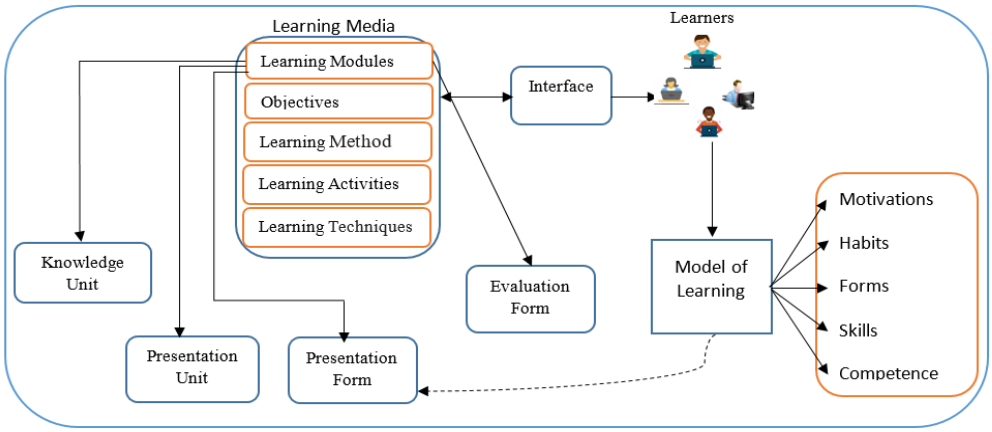

Figure 1. Top layered architecture (learning process)

3.2. Conceptual model layer

The objective of this layer is to define the framework of the actual process of LPs to the learners shown in Figure 2, the framework consists of four components: the knowledge unit which contains the definitions, methods, applications, activities, rules, and techniques of the LPs, the presentation unit which contains the examples, explanations, exercises, assignments, projects, and discussions of the LPs, the presentation form which contains text, video, audio, visual-silent, and audio-visual to present the LPs, and the evaluation form which contains quiz, calculation, multi choice question, task project, and participation of learning module and the relationship between the different units.

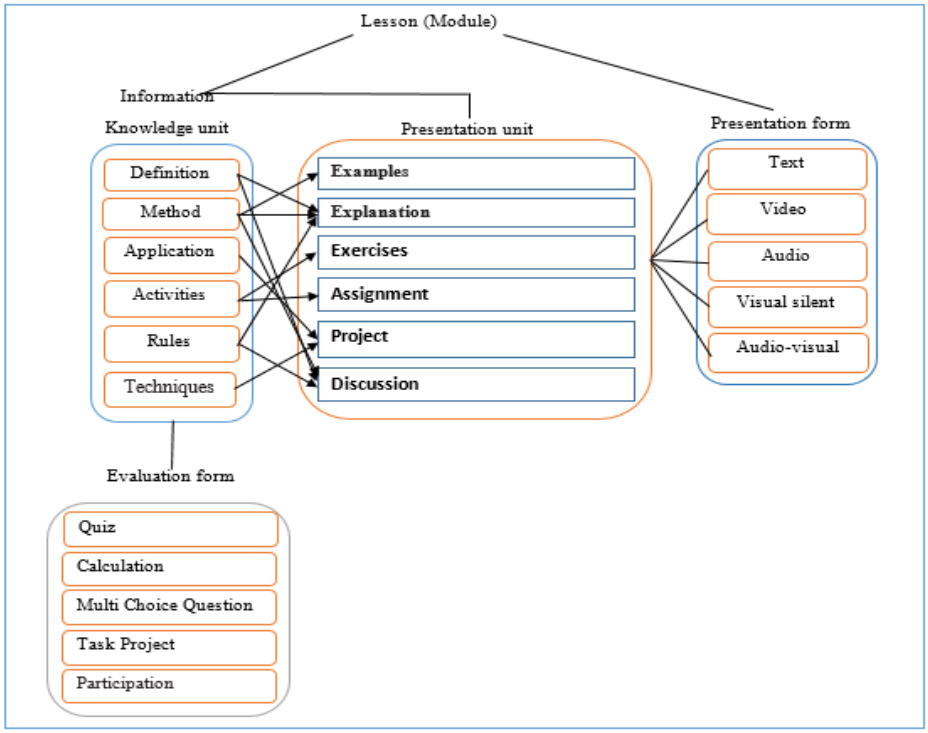

Figure 2. Conceptual model layers

3.3. Course ontology model

The course in education is a unit of teaching offered by an educational institute or organization to a group of students and led by one or more instructors [4]. For the variety of domain that different courses are involved, the development method of ontology is also not the same. So, there is no key method to build ontology models.

Concerning on reusability and maintainability, we take ontology engineering methodologies' developing steps to develop course ontology. At the same time, considering the special domain of e-learning course, with different users and different education level focused. The objective of this model is to define the domain ontology model of the course ontology, the model consists of the participant who are the teacher, student, and the primary components of a course which are: learning objectives, teaching methods, learning contents, learning media, and assessment, and then the other components of the course structure. shown in Figure 3.

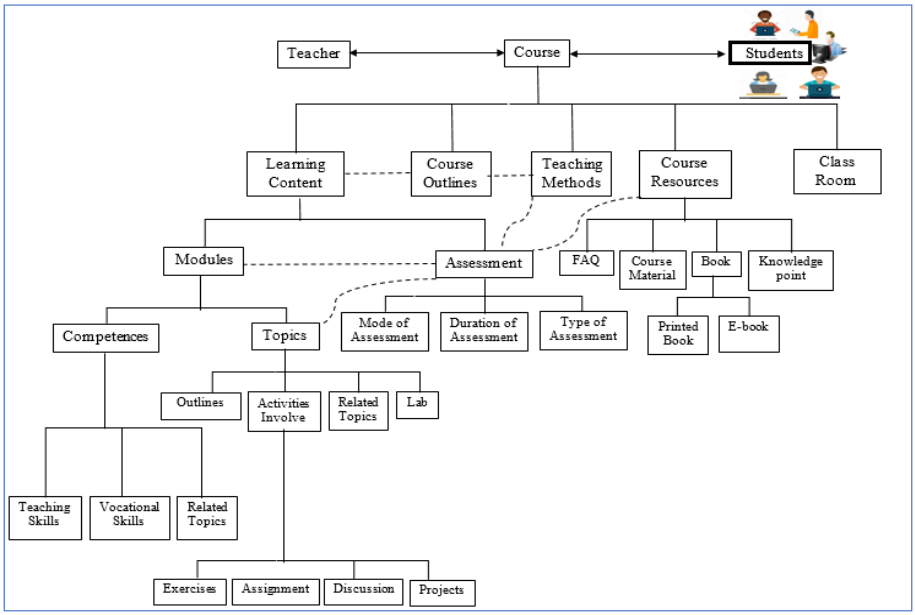

Figure 3. Course ontology model

4. ONTOLOGY MODEL OF LEARNING PROCESS CASE STUDY

Our research goal concerns the richness of the ontological modeling to support the course ontology. In this work, we address fundamentals of database systems course as a domain knowledge unit as a case study. Figure 4 is an example to explain the process of learning. Of course, the explanation depends on the topic, concept, and task used to represent the knowledge base of the domain module. Figure 4 shows a case study of a relational data model from the database domain. A data model is a collection of concepts that can describe the structure of a database.

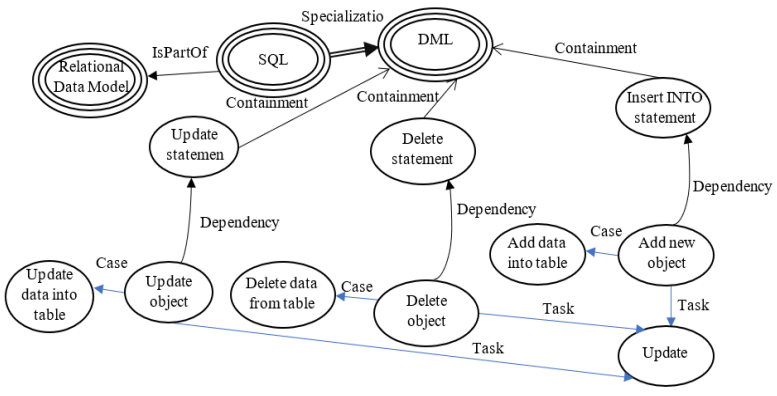

Figure 4. Example of knowledge representation of relational data model

4.1. Ontology implementation of course ontology using protégé

Protégé is a free, open source ontology editor and knowledge-based framework. The Protégé platform supports two main ways of modeling ontologies via the Protégé-frames and Protégé-OWL editors.

Protégé ontologies can be exported into a variety of formats including RDF(S), OWL and XML schema. Moreover, we use protégé 5.5.0 (protégé, 2018) and OWL2 language. Annotations were also made on the ontology itself. Figures 5 and 6 shows example of classes and properties of object definitions. The constructed ontology applying protégé can be managed by Java web ontology language-application programming interface (OWL-API). Java OWL-API is an open-source Java interface and implementation for OWL 2 [38]. OWL-API covers an API for OWL 2 and an efficient in-memory reference implementation, parsers and writers for various syntaxes, support for integration with OWL reasoners, and support for black-box debugging [38]. Figures 7 and 8 shows Ontology implementation of database course using protégé.

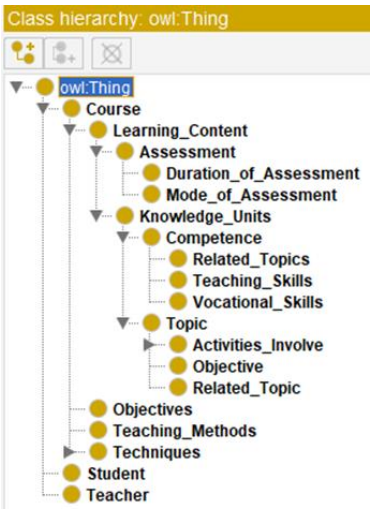

Figure 5. course ontology implementation using protégé

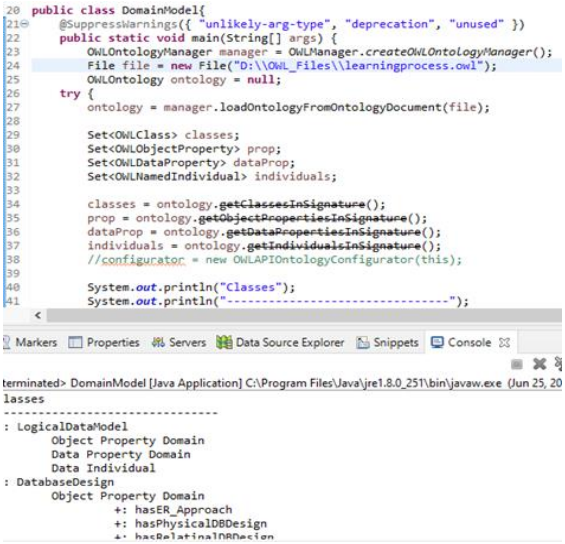

Figure 6. Snapshot for managing ontology course and in Java OWL-API

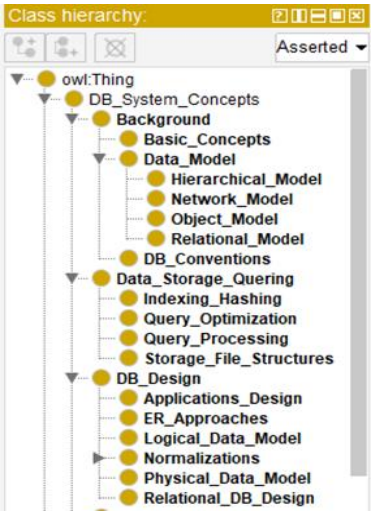

Figure 7. Database course ontology using protégé

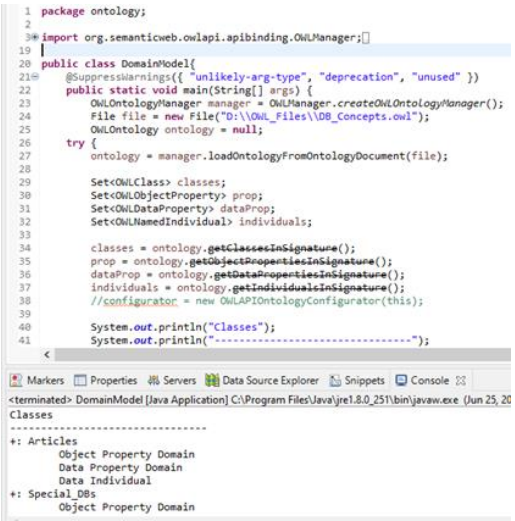

Figure 8. Snapshot for managing DB course ontology in Java OWL-API

4.2. The proposed ontology evaluation process

Evaluation of ontologies has become very important in the field of ontology engineering. The evaluation of the proposed ontology is done by ontology pitfall scanner, it is an online tool help to detect the most common pitfalls when developing the ontologies. It depends on some criteria which are Structure Dimension compute various structure properties in order to evaluate a given taxonomy, functional dimension

check the real world modelling or common sense, requirements completeness, and application context of the ontology, usability dimension measure clarity, understanding and metadata of ontology, consistency describes that the ontology does not include or allow for any contradictions, completeness measures if the domain of interest is appropriately covered in this ontology and conciseness is the criteria that state if the ontology includes irrelevant elements with regards to the domain to be covered. Figure 9 show snapshot of the tool and the covered criteria.

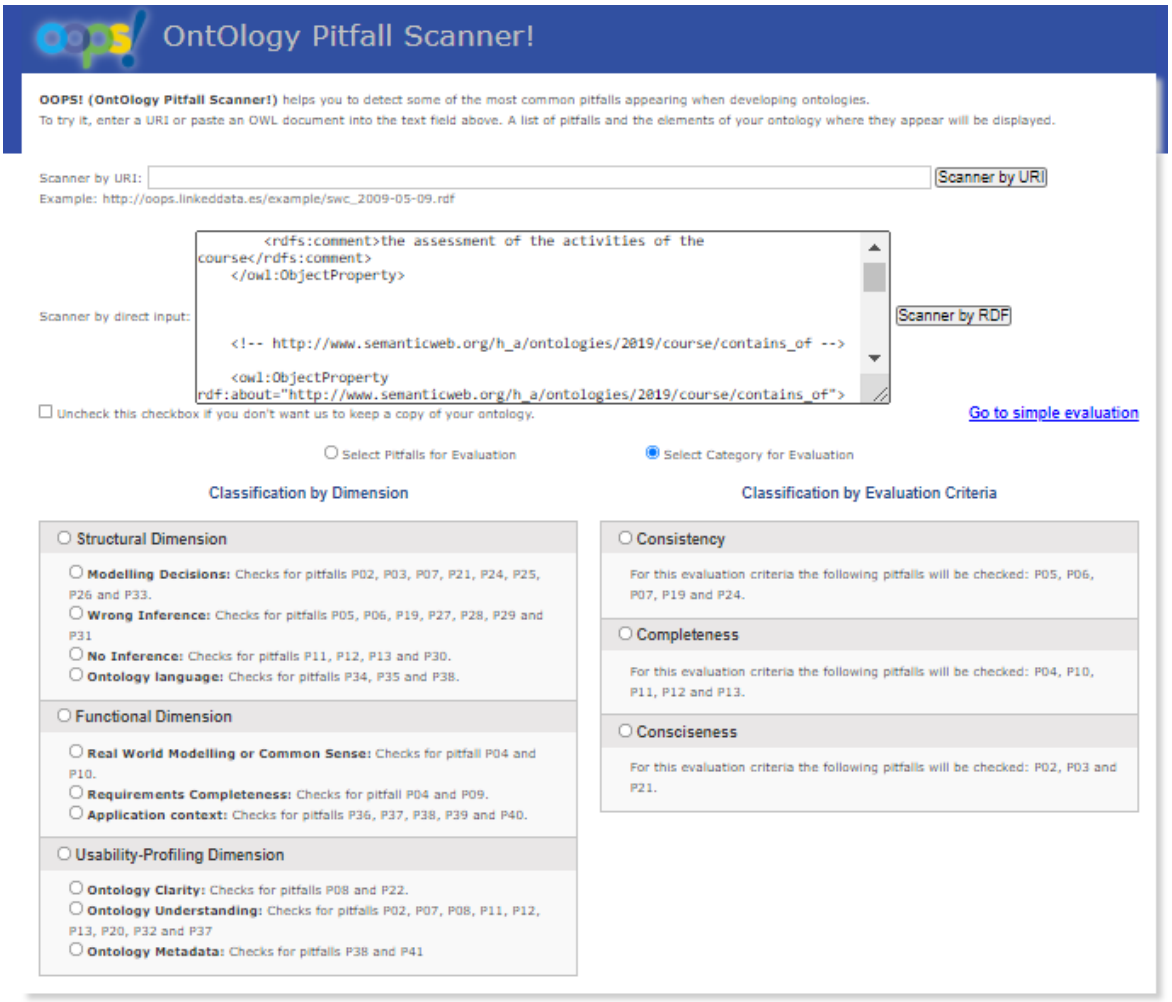

Figure 9. Snapshot ontology pitfall scanner tool

5. RESULT AND DISCUSSION

There are some methods in the literature used as a representation of domain knowledge for e-learning systems like DITA, moodle. DITA is a standard way for represention of information, it enables interchange and interoperation of XML content from a wide variety of sources without requiring everyone involved to agree on a single overarching document type defnition, and enable reuse of content among different publications and within the same publication [39]. The problem of DITA, it is handled by a human [39]. The whole learning process depends on the human teacher, add content (domain knowledge units), feedback, assessment, and so on. Most of these models are focused on solving a single domain and they try to create only a single domain like, teaching English grammar [40] and learning Java objects [41]. Lightweight domain model adaptive learning framework (ALEF) is designed to be related to domain of software engineering and programming [42]. ontological model for representing a learning resource as a domian ontology, the model represented in XML fragment, this model presents the learning resources in hypermedia pages, it can integrate models from cognitive theories and ontologies for the adaptation of educational resources [43]. So this model doesn't solve the problem of learning style [43]. The extended Bayesian network representing domain knowledge is a good approach for updating the domain model and for

adaptation of an intelligent tutoring system, but the problem of this model, the update operation is simi-automatically, this means some update handled by the human teacher [44]. The adaptive web-based educational system (AWBES) domain model overcomes the limitations of incorporating the educational and pedagogical theory in describing and organizing the learning content of educational systems, but it is designed for an essential programming language course (C++) [45]. And some domain model uses an isolated knowledge-base, this local knowledge-base can provide only limited knowledge background. The limitations of the isolated knowledge-base are lack of reusability, lack of standardization, lack of flexibility, and it has limited knowledge. This problem can be solved by using ontology as a shared knowledge-based.

Most of the mentioned domain model uses an isolated knowledge-base, this local knowledge-base can provide only limited knowledge background. The limitations of the single knowledge base are lack of reusability, lack of standardization, lack of flexibility and limited knowledge. Regarding the problems mentioned before, we suggest that we can solve these problems by using ontology as a shared knowledge-based. Our proposed model introduces a description of general concepts, and we can use it for a different domain when designing e-tutor systems.

As a result, our model differs from others because it can solve these problems as mentioned before. The proposed model can solve the problem of the current ITS systems. The solution can meet the features of reusability, standardization, open knowledge and flexibility. By using the ontology domain model, we can avoid the problem of isolate database. The constructed ontology can be used in the future to control adaptive intelligent e-tutor frameworks.

6. CONCLUSION

In this work we proposed ontology model for learning process, the model includes three layers, conceptual layer; The objective of this layer is to determine the general structure of LPs to the learners, which consists of 1) the knowledge unit, 2) presentation unit, 3) presentation form and 4) evaluation form of the learning module and the relationship between the different units, conceptual model; The objective of this layer is to define the framework of the actual process of LPs to the learners, course ontology model; The objective of this model is to define the domain knowledge model of the course ontology. Ontologies can be used in several ways in software engineering. Specifically, in this paper we use ontology approach, the role of ontologies in learning processes to enhance e-learning, and to define the semantic understanding between all stakeholders which in turns helps in clarifying the knowledge structure to reduce terminological ambiguity and allow the sharing of knowledge. The proposed ontology model describes the concepts that are essential to the understanding of the e-learning domain. In this case, course ontology model provides a learning process to develop e-learning process at development or run time. Ontology development has been used in the proposed ontology model as a means to standardize the core elements of a learning process. Nowadays, the value of ontology is well-perceived in many areas and sciences with computer science and education to present increasing perspective. Combining ontology with LMS will bring significant changes in the way of education. Creation of domain ontology offers a clear architecture of knowledge, and strengthen the management of learning resources, the ontology model can improve the efficiency of development and resource utilization. The proposed model can solve the problems of current e-tutor systems. Also, can be used for different domains when designing e-tutor systems. And can reach the characteristics of standardization, reusability, flexibility, and open knowledge. By applying this model, we can avoid the problem of isolated databases. The constructed ontology can be used in the future to control adaptive intelligent e-tutor frameworks.

ACKNOWLEDGMENT

The described study was carried out as part of the EFOP-3.6.1-16-00011 “Younger and Renewing University - Innovative Knowledge City - institutional development of the University of Miskolc aiming at intelligent specialization” project implemented in the framework of the Szechenyi 2020 program. The realization of this project is supported by the European Union, co-financed by the European Social Fund.

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