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ON BUILDING LEGAL ONTOLOGY FRAMEWORK FOR E-LEARNING: A CASE STUDY IN VIETNAM

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Abstract. *Following digital transformation in education, ontologies have been widely applied to e-Learning environment such as learning process management, systemizing learning contents. With the needs for legal foundation in e-Learning activities, it is required to construct a legal-based ontology to form up a valid e-Learning knowledge model. This study proposes a legal ontology framework for e-Learning, named by EdLO, which covers: (i) learner profile; (ii) teacher knowledge; (iii) learning content; (iv) learning process; and (v) regulations of Vietnamese education system. The resulting ontology was shown to be reliable by an evaluation of domain experts. Its efficiency was ensured through SPARQL queries querying to the real e-Learning data of a Moodle system populated to the ontology. The feasibility of the EdLO framework was demonstrated through experiment results.*

Keywords: e-Learning, Legal ontology, Ontology-based knowledge model, SPARQL query

1. **Introduction.** In recent decades, e-Learning ontologies have had a sharp evolution which applied ontology in most aspects of e-Learning environment, i.e., specifying learners' profiles [1], describing learning contents [2], building learning paths [3] or supporting students' learning process [4] just to name a few. The overall picture of ontological applications in e-Learning domain was fully depicted in the reviews [5-7]; however, to the best of our knowledge, the legal aspect of e-Learning activities in general and the legal ontology for e-Learning in particular have not been studied thoroughly and extensively.

To be more specific, although numerous of Massive Open Online Courses (MOOC) have been active worldwide with millions of issued certificates, the legal foundation for these systems (e.g., copyright of learning content, certificate verification, cross-verification of certificates among different MOOCs, legal identification of learning process, certificate validation following nationally educational system) has not been considered holistically. This non-legal situation has become more serious when automated information exchange [8,9] and deep integration [10,11] have been popular in e-Learning environment with the support of ontologies. This situation reveals a big gap between the vivid development of

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e-Learning systems and the unmentioned legal issues of e-Learning activities. In order to fill this gap, this study introduces a legal ontology framework for e-Learning, which is named as EdLO, to form up an e-Learning knowledge model seamlessly combining e-Learning domain knowledge and its related legal aspects. E-Learning activities are able to be legally supervised by this ontological approach. The proposed ontology covers: (i) learner profile; (ii) teacher knowledge; (iii) learning content; (iv) learning process; and (v) legal regulations of Vietnamese education system. An expert-based evaluation was conducted to validate the quality of the ontology and real e-Learning data of a Moodle system was populated to the ontology in order to verify the efficiency of the proposed ontology through SPARQL queries. Experimental results confirmed the usage of EdLO.

The rest of this paper is organized as follows. Section 2 presents a systematic review of recent studies in the fields of e-Learning ontology, legal ontology and analyzes typical ontological applications in different countries including Vietnam. Section 3 describes the EdLO framework in detail, while the validation processes are introduced in Section 4. Section 5 summarizes the results and outlines the future research targets.

2. **Literature Review.** In 2001, Berners-Lee et al. [12] introduced the Semantic Web initiative which uses ontology to build knowledge model through the process of knowledge specification. Therefore, different Ontology Engineering Methods (OEM) have been studied and introduced to [13-15]. At the beginning, OEMs were manual process, hence ontology learning methods, which are based on linguistic, statistic or machine learning methods [16-19], were applied to automating or semi-automating several steps of the process. In order to digitalize and describe different sematic levels of ontologies, a family of Semantic Web languages was presented. For instance, the Resource Description Format[1] (RDF) is used to describe unique resources, while its extension named RDF-Schema[2] (RDFS) provides the ability of class description for resources. Moreover, the Ontology Web Language[3] (OWL) and its second version – OWL-2 enable to specify rich knowledge about things. The OWL family has three members including OWL Lite, OWL DL and OWL Full supporting simple semantic constraints, description logic abilities and maximum semantic expressiveness, respectively.

Based on the above solid foundation, e-Learning ontologies have been introduced to the literature in many aspects. For instance, the ontology-based learner's profile enabled e-Learning systems can provide learner better personalized learning recommendations [1,20,21]. In another approach, ontological knowledge models were built to capture teachers' knowledge in order to serve the learning process [22,23]. Additionally, ontologies has been used to model the knowledge of courses [24], learning paths [3], model integration [25], or semantic search in e-Learning environment [11] just to name a few. The whole picture of e-Learning ontologies and their applications are shown in the following surveys [6,26,27].

Although ontology has been applied in most aspects of e-Learning domain, the legal aspect of e-Learning activities has not been covered by this kind of knowledge model. In theoretical research, ontology was applied to legal domain reusing legal information web-wide, enhancing the decision-making process as well as providing lawsuit information for expert systems [28]. Legal ontology research community has introduced the uppermost ontologies, which can be reused for any advanced legal ontologies, to the literature, i.e., Legal Knowledge Interchange Format (LKIF) [29], Core Legal Ontology (CLO) [30] or Functional Ontology of Law (FOLAW) [31]. The researchers worldwide have contributed many legal ontologies for different sub domains, for instance, privacy data protection [32], intellectual property right modelling [33], or criminal domain [34]. In Vietnam, the

[1]https://www.w3.org/RDF/
[2]https://www.w3.org/TR/rdf-schema/
[3]https://www.w3.org/OWL/

efforts of developing legal ontologies following Vietnam legal system received a very small number of studies. Recently, typical researches are as follows. Bui et al. [35] presented a Vietnamese legal ontology reusing LKIF core ontology [29]. The authors constructed their legal ontology following a four-step process including: (i) partially reusing ontologies; (ii) extracting chunks; (iii) selecting terms; and (iv) populating and classifying domain concepts. This ontology served the information retrieval tasks. Huy and Wuwongse [36] paid attention to the semantic search of Vienamese legal document. The authors modelled the legal documents using RELAX NG schema and RDF. Then, a Java and Jena based application was developed to implement the semantic search.

Although many legal ontological studies have been introduced to the literature, the legal ontology for e-Learning did not receive much attention. Hence, this research presents a legal ontology for e-Learning activities, that captures e-Learning knowledge and regulation of educational laws of Vietnam in order to introduce a novel ontological approach to e-Learning research field.

3. EdLO – Educationally Legal Ontology Framework.

In this section, we first describe the EdLO framework in both general architecture and intended usage in Subsection 3.1. Then, the specification of legal ontology and e-Learning ontology are presented and summarized in Subsection 3.2. Thirdly, the EdLO ontology, which is constructed on top the above two ontology layers and is further enriched by an SWRL rule base, is fully explained in Subsection 3.3.

3.1. The architecture of EdLO.

The architecture of EdLO framework focuses on the abilities of integration, reusing and expansion of different e-Learning ontologies, legal ontologies and common ontologies. Therefore, a layer-based architecture is proposed to match these design targets. Figure 1 depicts the main components of this framework.

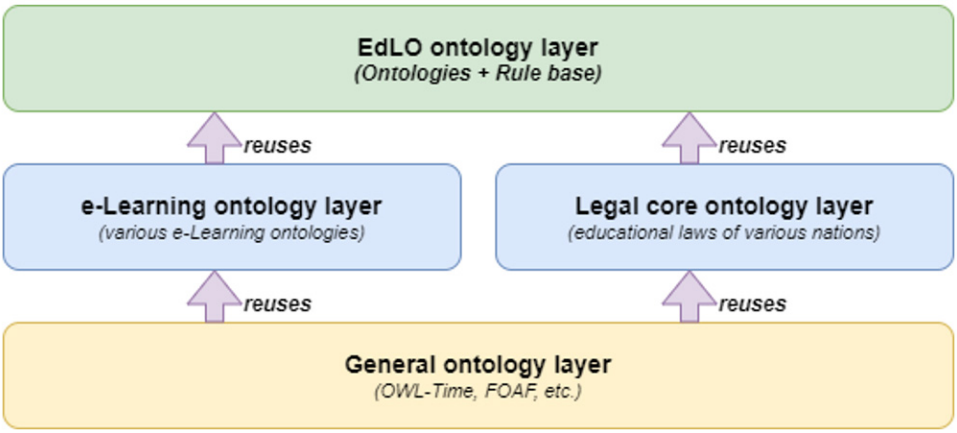

Figure 1. The EdLO framework

To be more specific, the common ontologies (e.g., FOAF, and OWL-Time) reside in the bottom layer, while the middle layer contains two domain core ontology components: e-Learning ontologies and legal core ontologies. The former can be constructed from scratch or be reused of the previous e-Learning ontologies, while the latter presents different legal knowledge models for different countries. These domain ontologies may reuse the common ontologies fully or partially. In this research, we target at linking common ontologies, legal knowledge models and e-Learning knowledge models into a unified knowledge structure. Hence, the top layer, where EdLO ontology and its rule base stay, is built on top of the aforementioned ontologies in order to provide a cutting-edge knowledge model of e-Learning which has solid background of both e-Learning and relevant legal regulations.

3.2. **The EdLO ontology engineering process.** The EdLO ontology engineering method is different from those of most other domain ontologies. The main reason is that while most of the other ontologies are one domain ontologies, EdLO ontology covers two major different domains including e-Learning and legal. Therefore, the distinct ontology engineering process of EdLO is summarized as follows.

Firstly, experts of both legal domain and e-Learning domain are invited to join the research. They and ontology engineers are then made familiar with the collaborative project environment, which uses Protégé [37] and Github as the ontology development tool and the collaborative working space, respectively. Secondly, the elements of the general ontology layer (e.g., FOAF or OWL Time) are figured out by the ontology engineers and domain experts. Thirdly, the legal core ontology layer (e.g., Law core ontology or Political structure ontology) and the e-Learning ontology layer (e.g., ontologies of user profile, and learning process) are built up separately and simultaneously. Each middle layer is developed by the collaboration of the correspondent domain experts and ontology engineers, in which, an iterative approach is applied to building each ontology of the middle layer until all of the participants reach consensus. Figure 2 and Figure 3 depict the excerpts of legal core ontology and e-Learning ontology, respectively. In Protégé, relationships among classes are created by object properties where the source and the destination of a relationship are the domain class(es) and the range class(es) respectively. Light-blue solid arcs are used to represent is-a-subclass-of relationships (e.g., the arc from class of *Learning_Material* to class of *Question* in Figure 3). Other dashed arcs in different colors illustrate relationships defined by domain and range classes (e.g., the relationship of *edlo:is_responsible_for* between classes of *Teacher* and *Course* in Figure 3).

To be more specific, within the scope of this research, the legal ontology is constructed based on the legal system of Vietnam and the Vietnamese legal normative documents are

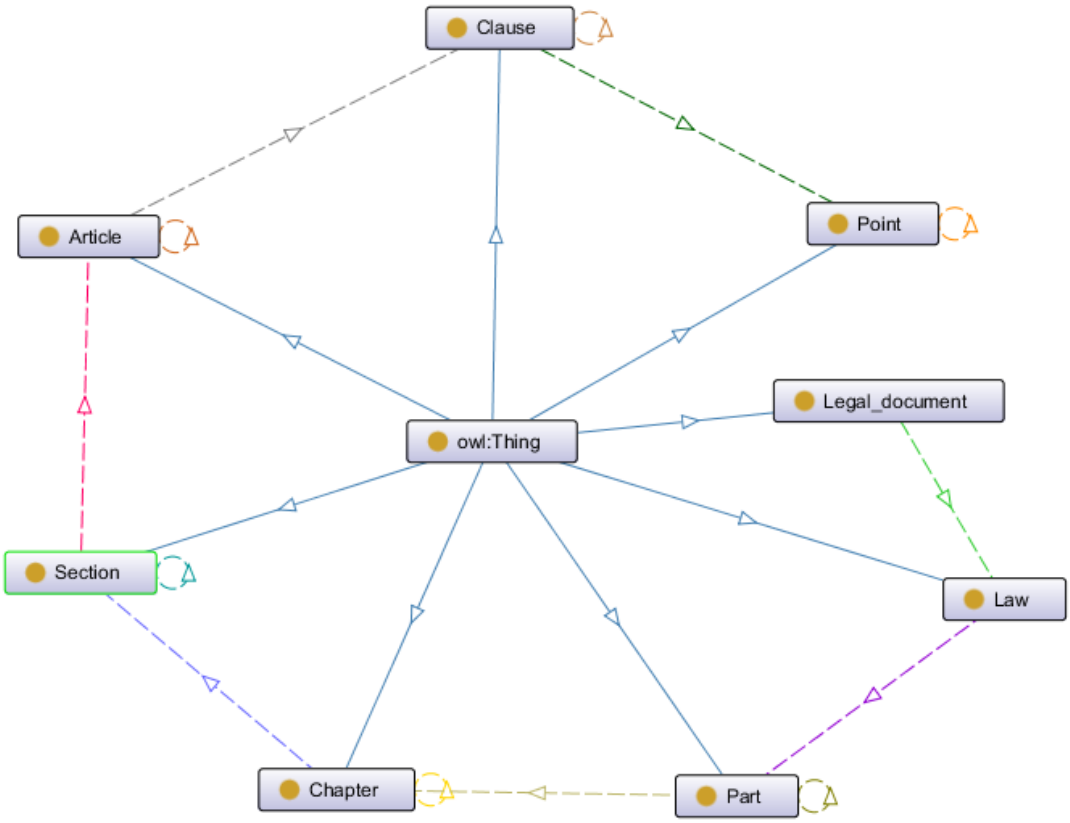

FIGURE 2. (color online) An excerpt of legal core ontology

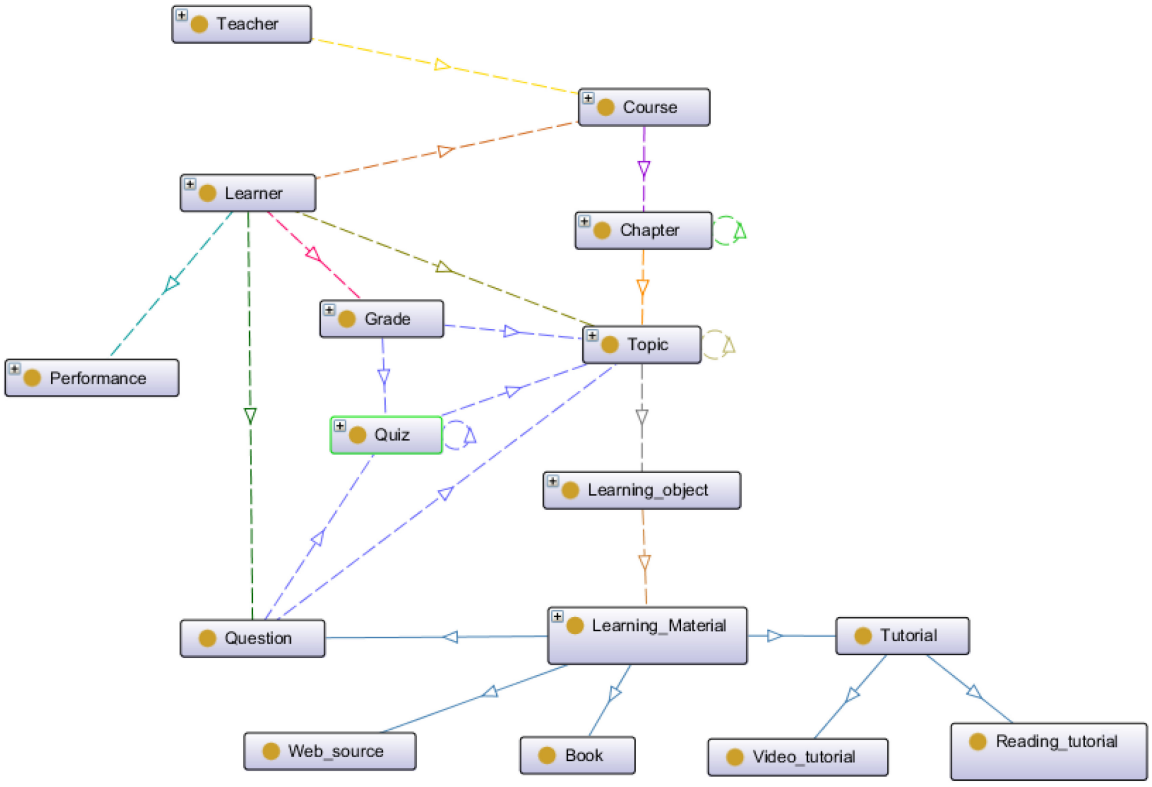

FIGURE 3. (color online) An excerpt of e-Learning ontology

collected from the official government website[4] in order to serve the ontological building process. The legal ontology is populated by the relevant laws such as Education Law, the Resolution of guiding to implement the Education Law. As for the e-Learning ontology, domain experts and ontology engineers build it from scratch but several concepts (e.g., Group, Learner, Course, and Topic) have equivalent meaning with Moodle tables. The two main reasons include (i) Moodle is the most popular e-Learning system in Vietnam; (ii) Moodle data can be populated to e-Learning knowledge model. Finally, this iterative approach is applied to building the EdLO ontology layer where legal knowledge is seamlessly integrated into e-Learning knowledge in order to form up a unique legal e-Learning knowledge model. An excerpt of the EdLO ontology is shown in Figure 4, which specifies the process of issuing an e-Learning certificate related to not only e-Learning operational concepts but also relevant legal classes.

To sum up, although the illustration of ontologies in this research is focused on the case study of Vietnam, the proposed OEM of EdLO can be applied to building ontologies for any other legal systems and different aspects of e-Learning. Additionally, the EdLO OEM does not limit to the ontological construction from scratch but supports reusing, expanding and integrating with other available ontologies as well. The proposed OEM of EdLO enables and targets at capturing knowledge precisely and flexibly.

3.3. **Rule base construction.** In order to enrich the EdLO knowledge model, we construct an SWRL rule base which is based on three main rule groups including (i) the original legal rules of legal documents; (ii) rules derived from e-Learning experts; (iii) rules operating on both legal domain and e-Learning domain. Table 1 lists three rule examples in accordance with the above three rule groups. The rule base resides in the top layer of EdLO framework and is developed after the process of building and/or reusing

[4]http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban

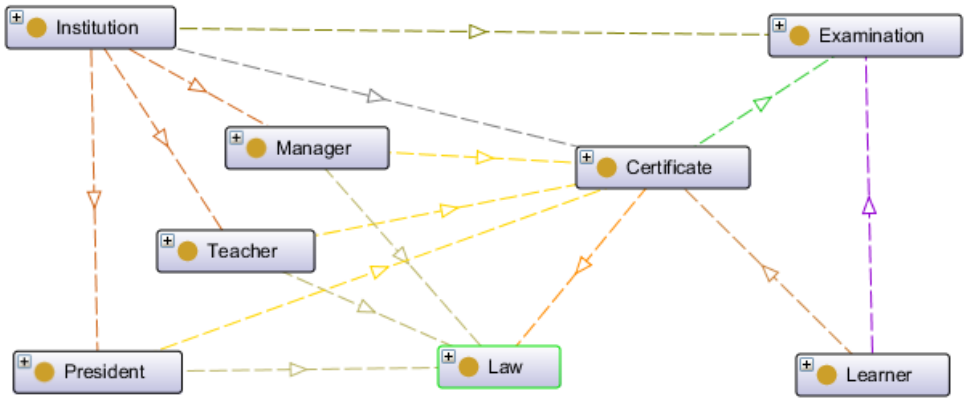

FIGURE 4. (color online) An excerpt of the EdLO ontology

TABLE 1. Examples of SWRL rules

No.	SWRL rule
1	[Rule 1]: Law(?i) ∧ Certificate(?c) ∧ satisfied_law_requirements(?c, ?l) → is_legal_certificate(?c, true)
2	[Rule 2]: Learner(?l) ∧ fail_exam(?l, ?e) ∧ Video_tutorial(?v) ∧ relates_To(?v, ?e) → suggest(?l, ?v)
3	[Rule 3]: Institution(?i) ∧ Manager(?m) ∧ Final_Exam(?fe) ∧ Learner(?l) ∧ Law(?law) ∧ can_grant_certificate(?i, true) ∧ has_manager(?i, ?m) ∧ sastisfied_law_requirements(?fe, ?law) ∧ can_sign(?m, true) ∧ checked(?m, ?law) ∧ passed(?l, ?fe) → grants(?m, ?cert) ∧ receives(?l, ?cert)

ontologies in the three layers of EdLO completed. In sort, SWRL rule format is as follows:

$$antecedent \rightarrow consequent$$

where both *antecedent* and *consequent* are constructed by the conjunctions of atoms $a_1 \wedge a_2 \wedge \cdots \wedge a_n$. Variables are denoted by the prefix of question mark (e.g., ?name) and links between instances, which are represented by relevant variables, and are constructed by ontological relations.

To be more specific, we summarize the construction process and describe a typical example of each rule group. For the first rule group extracted from legal documents, experts analyze rules of legal documents and determine the antecedents as well as the consequents. Then the ontology engineers encode these components in SWRL format. For example, the regulation "Certificate is only legal if it satisfies all related requirements of law" is transferred to SWRL rule as in Rule 1 of Table 1.

For the second and the third groups, experts' rule-based knowledge is firstly written down following antecedent-consequent structures. Then, the ontology engineers transfer the written rules in natural language to SWRL rules. For the second group, the teaching hint of giving further video tutorial for a given learner who failed a certain examination is expressed in Rule 2 of Table 1.

As for the third rule group, the Rule 3 of Table 1 expresses the regulation of issuing an e-Learning certificate legally if and only if the institution has the right to grant certificate and learner participated and passed the examination and the examination is allowed legally and the manager has right to sign the certificate and he/she checked all relevant legal documents. In summary, the time intensive process of building SWRL rule base produced the following results: 115 rules of group 1; 27 rules of group 2; and 23 rules of group 3.

4. **Ontology Validation.** In order to evaluate the quality of EdLO ontology, we applied the goal-question method [38] to investigate the experts' agreement about EdLO ontology through five-scale Likert rating. Additionally, the performance of EdLO knowledge model was also validated through SPARQL queries over real data retrieved from a Moodle-based e-Learning system of a public university in Vietnam.

4.1. **Evaluating the quality of EdLO ontology.** In this evaluation, we built up questions to investigate the experts' evaluation about the EdLO ontology over the following four goals: (i) domain and scope; (ii) the structure and relationships; (iii) the ability of reusing and integrating; (iv) the feasibility and efficiency of the cross-domain ontology. Answers were measured following five-level Likert scale including 1-strongly disagree; 2-disagree; 3-neither agree nor disagree; 4-agree; 5-strongly agree. Table 2 shows the questions used to evaluate three components of EdLO knowledge model: (i) e-Learning ontology (eLO); (ii) legal core ontology (LCO); (iii) EdLO ontology at the third layer.

Table 2. The verified questions used to evaluate ontologies

Goal	Question	eLO	LCO	EdLO
1	Q1: Did the ontology cover its domain and scope?	✓	✓	✓
	Q2: Did the ontology correctly describe the domain knowledge?	✓	✓	✓
	Q3: Did the cross-domain ontology utilize the available specific domain ontologies?			✓
2	Q4: Do you agree with the ontological structure?	✓	✓	✓
	Q5: Do you agree with the proposed class attributes (concept relations)?	✓	✓	✓
	Q6: Do you agree with the proposed data attributes?	✓	✓	✓
3	Q7: Did the ontology reuse other common ontologies efficiently?	✓	✓	✓
	Q8: Was other domain ontology integrated successfully into the current domain ontology?	✓	✓	
4	Q9: Do you agree that EdLO ontology can be deployed efficiently in real applications?			✓
	Q10: Do you agree that the legal knowledge was successfully integrated to EdLO ontology?			✓
	Q11: Do you agree that the e-Learning knowledge was successfully integrated to EdLO ontology?			✓

Quality evaluation was carried out through experts' rating for verified questions. 7 experts in e-Learning domain and 7 experts in legal domain were invited to this evaluation process. These experts either hold Ph.D. degree or are Ph.D. students in their domain. While the legal experts evaluated the legal core ontology, the e-Learning experts rated the quality of e-Learning ontology. Both groups also answered verified questions of EdLO ontology of the third layer. Their answers were five-level Likert scale rating which were used to measure the average agreement of experts about the quality of ontologies in EdLO framework. The average results are shown in Figure 5 which figured out that all of the average results are greater than 3 and 7 groups over the total 11 groups have the average values approximate to or equal to 4. These average scores implied that experts agreed with the quality of EdLO ontologies.

4.2. **Validating EdLO ontology.** In order to check the integration of EdLO knowledge model, we populated real data for ontologies of EdLO and then checked the performance

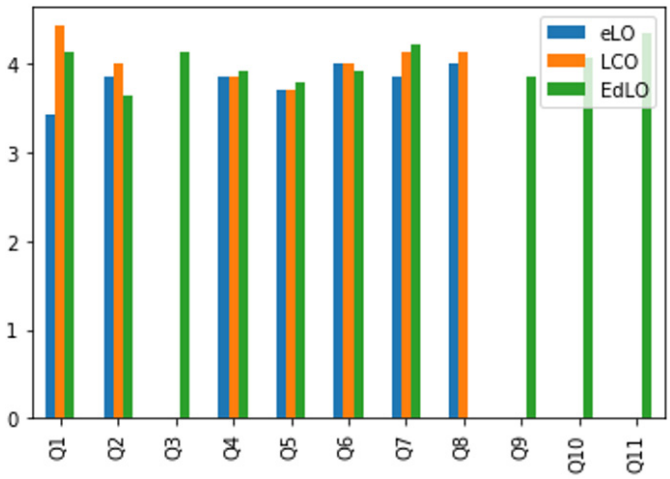

FIGURE 5. Average evaluation results of experts

through the implementation of SPARQL queries. The real data, which come from Vietnamese legal regulations of education and Moodle-based e-Learning system of a public university, had been populated to EdLO knowledge model. This model was run in a 64-bit Ubuntu-based server which was deployed an i7 core CPU, 32 GB of RAM and 1 TB of HDD. The free and open source edition of Virtuoso Universal Server[5] was used to store EdLO ontologies and their populated data.

The following examples of SPARQL queries investigated the structure of EdLO knowledge model and retrieved semantic data. The purposes of investigating EdLO ontologies were to serve the task of developing this knowledge model, while the purposes of retrieving semantic data are to provide data for further data-driven tasks (e.g., data analysis, data visualization and display). Query results and performances are presented in Table 3 and Table 4.

TABLE 3. Investigating structures of the EdLO knowledge model (prefixes are excluded)

(a) Retrieve all concepts (classes) of EdLO ontology	

SELECT DISTINCT ?concept
WHERE {
?s a ?concept.
FILTER(STRSTARTS(STR(?type), str(edlo:)))
}
	Output (57 records in 0.28s)
	edlo:Institution/1/
	edlo:Certificate/1/
	edlo:Examination/1/
	...
	(edlo is the prefix abbreviation for the URI of EdLO ontology)

(b) Retrieve all relations between two concepts	

SELECT DISTINCT ?relation
WHERE {
?concept1 a edlo:Institution.
?concept2 a edlo:Certificate.
?concept1 ?relation ?concept2.
}
	Output (1 record in 0.002s)
	edlo:grants
	
	(edlo is the prefix abbreviation for the URI of EdLO ontology)

Specifically, the queries in Table 3 provide examples of investigating structure of the EdLO ontology through retrieving concepts or relations, while examples of retrieving and inferencing semantic data in the EdLO knowledge model are given in Table 4. Both tables

[5]http://vos.openlinksw.com/owiki/wiki/VOS

TABLE 4. Retrieving and reasoning semantic data (prefixes are excluded)

(a) Count the course participants	

SELECT count(DISTINCT ?student) as ?count {
?course a elo:Course.
?course elo:courseCode "CS101-X"^^xsd:string.
?student a elo:Learner.
?student elo:joins ?course.
}
	Output (1 record in 0.15s)
	57
	- "CS101-X" is filled in the query through template
	- elo is the prefix abbreviation of the URI of e-Learning ontology

(b) Display the list of graduated participants for the final examination of the course	

SELECT ?last_name, ?first_name {
?course a elo:Course.
?course elo:courseCode "CS101-X"^^xsd:string.
?student a elo:Learner;
elo:first_name ?first_name;
elo:last_name ?last_name.
?student elo:joins ?course.
?exam a edlo:Examination.
?exam edlo:is_exam_of ?course.
?student edlo:passed ?exam.
FILTER (lang(?first_name) = 'vn')
}
ORDER BY ASC(?first_name)
	Output (42 records in 0.22s)
	Đoàn Văn Anh
	Lê Văn Bình
	....
	- "CS101-X" is filled in the query through template
	- elo is the prefix abbreviation of the URI of e-Learning ontology
	- edlo is the prefix abbreviation for the URI of EdLO ontology

(c) Inference legal candidates for granting certificates	

CONSTRUCT{
?student edlo:is_legal_candidate "true"^^xsd:Boolean.
?student edlo:received_certificate "false"^^xsd:Boolean.
?cand_list edlo:has_members ?student.
?student edlo:is_in_candidate_list "true"^^xsd:Boolean.
} WHERE {
?student a elo:Learner.
?course a elo:Course.
?exam a edlo:Examination.
?course elo:courseCode "CS101-X"^^xsd:string.
?exam edlo:is_exam_of ?course.
?student elo:joins ?course.
?student edlo:passed ?exam.
?student edlo:is_in_candidate_list "false"^^xsd:Boolean.
}
	Implementation time: (1 minutes 37 seconds)
	
	- "CS101-X" is filled in the query through template
	- elo is the prefix abbreviation of the URI of e-Learning ontology
	- edlo is the prefix abbreviation for the URI of EdLO ontology

show the measurements of query results and their performances in number of returned records and implementation time, respectively. The results demonstrate the success integration of different ontologies in the EdLO knowledge model (e.g., e-Learning ontology and EdLO ontology) through the cross-domain selection of SPARQL queries (b) and (c) in Table 4.

5. **Conclusion.** This paper introduced a legal ontology framework for e-Learning, called by EdLO, to represent an e-Learning knowledge model for the legal-based e-Learning activities. The proposed ontology was constructed based on the three-layer framework which covers (i) learner profile; (ii) teacher knowledge; (iii) learning content; (iv) learning process; (v) regulations of Vietnamese education system. The feasibility of EdLO was proven by experimental results. The quality of the ontology was validated by an expert-based evaluation while its efficiency is verified by SPARQL queries querying to the real e-Learning data of a Moodle system populated to the ontology. To take advantage of legal ontology in e-Learning domain, researchers would face challenges of revision management of legal documents, automated extraction of rules that are topics to be explored in the future.

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