LEARNERS' PERFORMANCE EVALUATION AND KNOWLEDGE EXTRACTING USING ONTOLOGICAL REASONING

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ABSTRACT

Evaluating the learner's performance is one of the most frequent activates in both conventional and e-learning. It is considered as an evidence of acquiring knowledge during learning process. The test is one of the methods that are used to evaluate the performance of the learners in e-learning system, semantic web, on the other hand, provides a metadata to describe the meaning of web resources in order to move the web content from human-readable to machine-readable. In this paper we have taken the advantage of semantic web to add description to the learning materials using ontology. We have represents the learning materials and questions using their important semantic keywords; we have assigned a semantic value to these semantic keywords in each learning materials. We have evaluated the learner's performance by extracting the semantic keywords-which represent the acquired knowledge- from the answer of description questions. Then we have inferred the learner's profile to figure out the progress of learning and the concept to be learned in the next step.

KEYWORDS: *SWS, Ontology, SWRL, e-learning.*

I. INTRODUCTION

E-learning has become an alternative solution for the traditional learning. It has shifted the learning process from the teacher-control to learner-control[1]. From learner perspective this shift will give the learners more control to choose their learning materials and construct personal learning process. However, the learner's performance evaluation is considered one of the most common activity in e-learning systems [2] it is the evidence of greater knowledge transmission[3]. Test is one of tools that are used to evaluate learner's achievement. The traditional test involves a lot of manual operations from both lecturer and learner. These operations have been reduced in most of e-learning systems but there is a difficulty to evaluate the learning achievement of learner by reading the learner's answer [4]. Moreover, conventional test's questions in most of e-learning systems are based on multi-choice and true-false question. On the other hand the content of the e-learning system needs to store along with semantic description to move from human accessible to machine accessible [5].

One of the aims of E-learning is to make its contents broadly accessible, searchable and reused [6]. This content needs to store along with semantic description to move from human accessible to machine accessible [5]. Semantic web considered one of the hottest topics in recent year. It is offers a promising approach to e-learning environment which ensures machine-process ability and interchange ability. Semantic web provide a metadata to describe meaning of web resources in order to create environments that are capable of advance automatic processing of the web content by both human and software agents [7]. Ontology, defined as a representation of a shared conceptualization of a particular domain, is the backbone of semantic web. Ontology typically consists of description of concepts relevant for a particular domain, their relations and axioms about these concepts and relationships.

Many researchers have engaged the use of semantic web in their work for different purposes in E-learning systems such as storing and retrieving the learning materials [5], control the learners' acquired knowledge [8] and for generating learning path sequencing [9, 10]. The work [8] proposed an auto scoring mechanism to evaluate the learning performance using problem solve approach. The learner selects the best answer for the question form the system then he locates relevant information. The evaluation in this work is based on computing the similarity between two sets of keywords, one provided from the teacher and another from the learner's answer. Other researchers evaluate the learner by browsing the relevant record in learner's profile which considered a time/effort consuming [4,11]. The evaluation of learner's performance using intelligent scoring mechanism has been proposed for different type of questions (True/False, multiple choice, multiple response and multiple fill-in-blank) [12].

This study employs the ontology to describe the resources of e-learning system. We have extracted the knowledge and score the description question to evaluate the performance of the learner during the learning process. Reasoning used to infer the learner's performance at anytime during the learning process. The remainder of this paper is organized as follows: section 2 presents the problem description, semantic values calculation in section 3, section 4 presents the ontology framework and reasoning rule, and in section 5 we have described the learner's performance evaluation. Finally the paper conclusion and future work is presented in section 6.

II. PROBLEM DESCRIPTION AND FORMULATION

E-learning systems deliver the learning materials to the learners online. Most of these learning materials are web-pages and they lack of semantic description. Moreover, these E-learning systems have used the test to evaluate the learner's performance during the learning process based on special type of questions (true-false, fill in blank, multi choice). Sometimes when the learner answers true-false question, the learner might not be sure of the answer and his guess might come to be true. Marking the description questions is time/effort consuming. On the other hand, it is difficult to navigate the log file on the learner's profile to extract the concepts learned by the learner.

Representing the E-learning using Semantic web technology by adding annotation to the learning contents will add description to them. Moreover, representing the learning materials and their questions by semantic keywords in the ontology will allow the instructor to assign and mark the description questions for the learner during the learning process. The semantic keywords could be used to evaluate the learner's performance by using reasoning which is one of the features of semantic web.

The following steps are the steps that are used to evaluate the learner's performance using ontology:

Step1: Calculate the semantic value for the semantic keyword in each of learning materials.

Step2: Represent the learning materials along with their semantic keywords and semantic values in the form of ontology.

Step3: Assign description questions to the learners to evaluate their acquired knowledge.

Step4: Score the answer of the description questions using the semantic keywords in the learning materials' ontology.

Step5: Update the learners' profile by inferring the concepts learned and concepts to be learned during the learning process.

III. SEMANTIC VALUE CALCULATION:

In order to use the description questions to evaluate the learner's performance, we assume that the learning materials (chapter or courseware) and question bank are described in the ontology along with their semantic keywords. These semantic keywords have a semantic value according to the importance of the semantic keywords in the learning materials and it might be different from learning material to other. The computation for the important keywords in the courseware begins with eliminating the stop word and common English words. This step is to reduce the total number of keywords in the keywords-courseware list. Then the expert lecturer will select the important keywords among all the keywords in the keywords-courseware list to avoid the occurrence of unrelated keywords in the courseware. We construct the keywords-courseware list using the Vector

Space Model by computing the keywords' semantic value for each courseware. The keywords and their occurrence frequencies are represented in the matrix A as follows: $A = K \times Q$ Keyword-courseware matrix is k*q matrix, where K is keywords in Q courseware. This matrix represents one-row matrices and one-column matrices and these represent the vector. The Frobenius Norm of matrix (Euclidean Norm) is defined as the square root of the absolute squares of the matrix elements, which give the length of the vector. The semantic value $SVcw_i^{k_j}$ for the ith keyword k_i in the jth courseware cw_j is calculated according to the occurrence of the keywords in the courseware using Euclidean norm as follows:

$$SVcw_j^{k_i} = \frac{k_i}{\sqrt{\sum_{i=1}^{n} k_i^2}} \quad (1)$$

Where k_i is the occurrence of the keyword k in the courseware j. In table 1 we have shown part of keywords-courseware list for the course-work of Java programming language, the course-work consists of eight course-wares and we have extracted total of 75 keywords for all course-wares.
The semantic values of the keywords of the questions are different from courseware to other course-wares depends on the importance of the keyword in the courseware. For example, the keywords private has the following semantic values (0.26858, 0.1411165, 0.636119, 0.155952, and 0.556815) for the courseware cw2, cw4, cw5, cw7 and cw9 respectively. The highest values for this keyword is in courseware cw5 because the learning materials in cw5 are contain of class and object topic. We have used the calculation of keywords semantic values to generate dynamic learning path sequencing for learner according to his course selection[13].

Table 1 keywords-courseware list

Keyword	cw1	cw2	cw3	cw4	cw5	cw6	cw7	cw8
Array	0.348822	0.482561	0	0.543659	0	0	0.351984	0
Boolean	0.811214	0.841768	0	0	0	0	0	0
Character	0	0.369921	0	0	0	0	0	0.625712
Class	0.219156	0.9114	0.387956	0.448325	0.343542	0.298392	0.123194	0.387943
Data	0.29237	0.84176	0.771976	0.81259	0.339263	0	0	0.11125
Implement	0.648972	0	0.231593	0.336244	0.353373	0.693742	0	0.437997
Inheritance	0.486728	0.16835	0	0.141165	0.127224	0	0.211194	0
Instance	0.486728	0	0	0.215757	0.161983	0	0	0.23777
Interface	0	0	0.385988	0.758249	0.432568	0.146133	0	0.23777
Object	0.811214	0.128668	0.787416	0.285874	0.262929	0	0	0.888585
Private	0	0.26858	0	0.141165	0.636119	0	0.155952	0.556815
Protected	0	0	0	0.28233	0.824792	0	0	0.375426
Public	0.456693	0.112585	0.771976	0.33946	0.86717	0.18373	0.281587	0.437997
Subclass	0.456693	0.857788	0.671976	0.28233	0.279892	0	0	0

IV. ONTOLOGY FRAMEWORKS AND REASONING

Semantic Web is the extension of the current web [7], which built for the goal of better enabling machine and human to work in cooperation. The semantic web annotated the content with formal semantic. This make the content suitable for machine consumption which is intended built for human consumption and enable automated agents to reason about web contents and produce an intelligent response. There are various Semantic web languages for knowledge representation and semantic web reasoner to infer over it are available [14].Ontology is the backbone of Semantic web which appears as promising technology to implementing e-learning.
The Ontology is an explicit specification of conceptualization to describe and represent an area of knowledge. The concepts, their relationships and properties of concepts are expressed in ontology in hierarchical structure, the ontology provides a way to encode knowledge and semantic such that the machine can understand. Ontology enables to annotate the learning materials semantically. OWL (Web Ontology Language) is a standard for representing knowledge on the Web with a focus on both making these documents compatible with Web standards and on being useful for the modeling of knowledge using past research on ontologies and reasoning[15].

In this section we present the ontology frameworks developed to use in e-leaning environment to evaluate the learner's performance. The main components of our frameworks ontology are eBook and Person ontologies. The ontologies are developed using OWL-DL in Protégé editor.

4.1. eBook Ontology

Figure 1 shows the mapping ontologies diagram of eBooks their relationships to other components. The class EBOOK used to annotate the resource which is a book. The class EBOOK has one subclass is chapter; two object properties are *haschapter,* and*hasAnother*; and four Data property: *hasPublisher*, *hasLanguage*, *hasData* and *hasBookTitle* . The subclass chapter has seven subclass are *course material, example, assignment, test, image, table, exercise and SemanticKeywords*; data properties are *hasConcepts, DifficultyLevel, hasSemanticValue*, and *hasPrice* which we are going to use in this work..

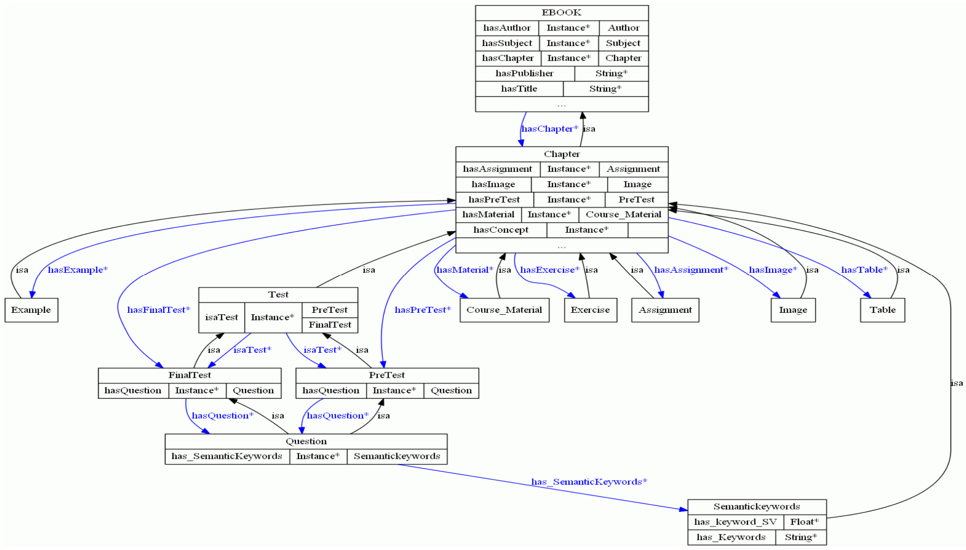

Figure 1 the mapping ontology diagram for the EBOOK ontology

The object property *has Author* identifies the Author. The author, lecturer and Learner and their role are defined in Person ontology.

The class chapter is used to describe the content fragments. The data property *hasConcepts* holds the information of the contents available in particular chapter in "Java programming language "book, chapter titled "Interfaces_and_Inheritance" has the following concepts: "Implementing an Interface","Inheritance","Overriding and Hiding Methods","Polymorphism","HidingFields","Using the Keyword super","Object as a Superclass","Writing Final Classes and Methods","Abstract Methods and Classes". Chapter represents different type of materials. It means that the materials might be a study materials (concepts) or examination materials (pre-test and final test), Chapter and PreTest and FinalTest are related through *hasPreTest and hasFinalTes* propertiesrespectively. The data property *DifficultyLevel* identifies how hard the chapter or learning materials are to work with. The measure of the difficulty of the materials is based on how many semantic keywords in the learning materials and how much the semantic values the chapter or the learning materials is currying, we identified three levels namely Low, Medium and Hard. The data property *hasSemanticValue* gives the weight of the chapter based on the importance keywords in the chapter as we computed in previous section. The subclass semantic keywords identify all the semantic keywords in the chapter along with their semantic values, these semantic keywords might be assign to the questions of pretest or/and final test. The prices of the chapters are assigned by the Service provider as the money the consumer (learner) is willing to pay for the chapter and it represents in the property *hasPrices*. The property *hasKeywords* and *hasConcepts*are a list of important keywords and concepts in the chapter respectively.

4.2. Person Ontology:

The person ontology presents three types of users namely, Learner, Author and Lecturer and their relationship with other components in the framework figure 2. The learner has different learning styles and different performance. In the ontology we present the performance of the learners as subclass of learner class. The performance of the learner during the learning process is measured by the acquired concept. In the performance class we have defined threesubclassess: Backgroundknowledge, ConceptLearned and ConceptToBeLearned subclass.

The Backgroundknowledge subcalss contain the semantic keywords of the concepts the learner know before joint to the course. A pretest is assigned to the learner to evaluate his background knowledge. The semantic keywords of the question's answer of the pretest are stored as instance of Background knowledge subclass of the particular learner. The ConceptLearned contain the semantic keywords of the concept learned during the learning process, these semantic keywords are stored as instance of ConcpetLearned after evaluate the Final Test of each courseware learned. The semantic keywords in ConceptToBeLearned represent the concepts which are left and the learner should to learn them. These semantic keywords are inferred during the learning process to evaluate the learner's performance, and the instances of the ConceptToBeLearned subclass are not instances of the Backgroundknowledge subclass neither the conceptLearned.

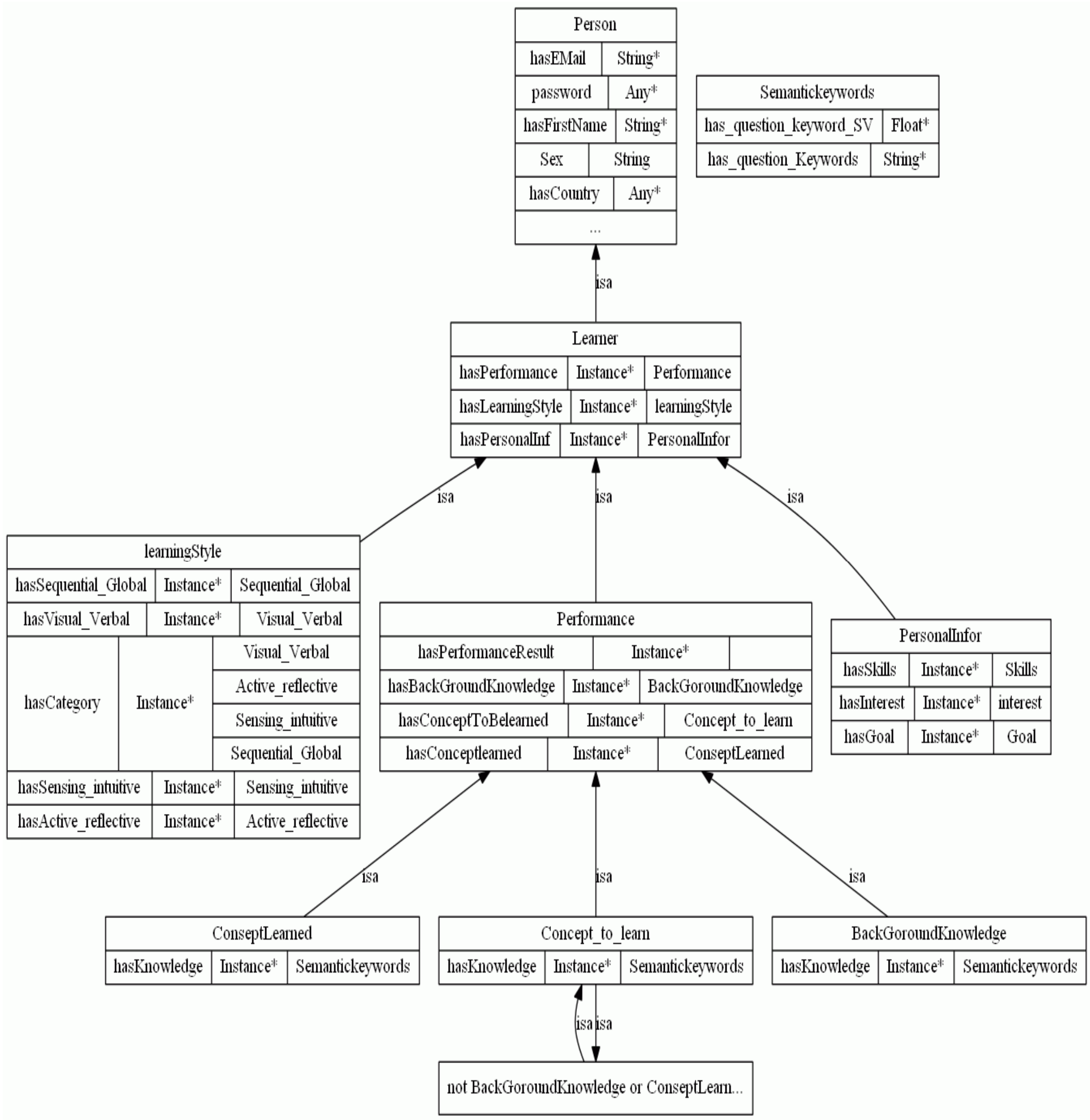

Figure 2 the mapping ontology diagram for the Person ontology

4.3. Reasoning Rules:

Reasoning is important in Ontolgies and Knowledge base especially in deriving or inferring facts that are not expressed in ontology or in knowledge base explicitly. An OWL in the abstract syntax is contains of sequence of Axioms and facts. The rule consists of an antecedent and a consequent, each of which consists of sets of atoms (possible empty). The rule has the syntax form (Antecedent ➔ Consequent). For example, in the family ontology includes Person, Man, Woman and Child, and relationship such as hasSibling. A rule that defines Brother involving Person and Man can be written:

Person(?p) ∧ hasSibling(?p, ?y) ∧ Man(?y) →hasBrother(?p, ?y)

hasBrother relation cannot be expressed by OWL Ontology directly because OWL has limitations in reasoning.

SWRL (Semantic Web Rule Language) is defined to combine OWL ontology (DL, Lite) sublanguages with Rule Markup language. SWRL extends the set of OWL axioms to include Horn-like rules, enabling the combination of SWRL rules and OWL knowledge base[16].

In this work we have used Protégé together with "SWRLTab" plug-in to enable domain editing, construct, management, visualization and reasoning the ontology. a free open-source ontology editor developed by the Stanford Medical Informatics (SMI) at Stanford University [17], which is an integrated software environment for system developer and domain experts to develop knowledge base system. "SWRLTab" is Protégé's plug-in which supports the editing and executing SWRL rules and it includes a set of libraries that can be used in rules. It also provides OWL query language through SQWRL [14]. SWRLTab is the bridge between the OWL model and SWRL rules and JESS (Java Expert System Shell) rule engine. Moreover, we have used OWL-API to execute this rules from java platform [18].

We have developed several SWRL rules for inferring the relationships between individuals figure 3. Here we present some of the rules:

- This rule is to infer the chapters that have semantic value greater than "7" in ebooks provided from different SPA's is as follow:

Chapter(?chpt) ∧ hasSemanticValue(?chpt, ?swv) ∧ swrlb:greaterThan(?swv, 7) → Chapter(?chpt)

This rule is to infer the Author name for chapter in ebook is

hasChapter(?x1, ?x2) ∧ EBOOK(?x2) → hasAuthor(?x1, ?x2)

This rule is applied to identify the authors in which subject their books.

Author(?pr) ∧ isAuthorOf(?pr, ?eb) ∧ hasSubject(?eb, ?sub) → AuthorInSubject(?pr, ?sub)

This rule is applied to identify the SPAs and their support subjects

SPA(?sp) ∧ hasSearchin(?sp, ?eb) ∧ hasSubject(?eb,?sub) → SPAinSubject(?sp,?sub)

- This rule is applied to infer the concept that the learner_1 have to learn during the leaning process.

  Learner(Learner_1) ∧ hasPerformance(Learner_1, ?x) ∧ hasConceptToBelearned(?x, ?y) →

  hasKnowledge(?x, ?w)

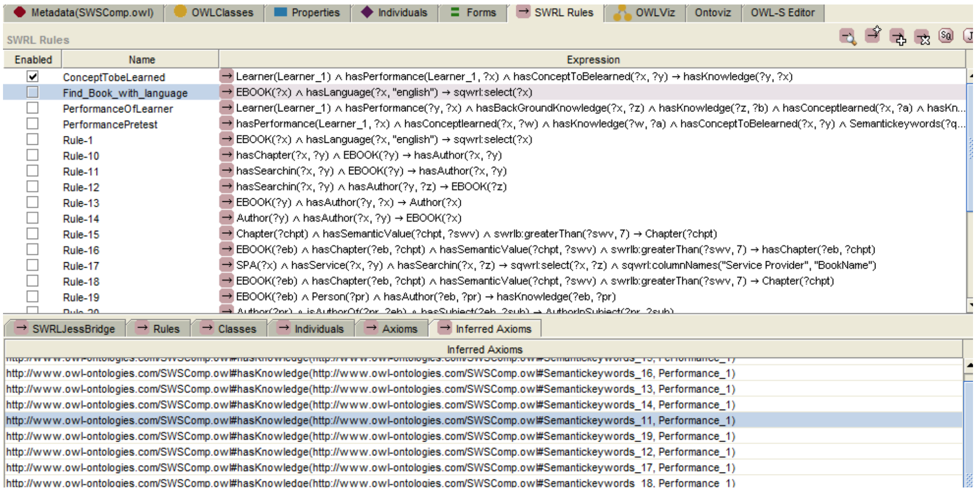

Figure 3 SWRLTab in Protégé for infer rules

V. Learner's Performance Evaluation using Knowledge Extraction

We can evaluate of the learner's performance during the learning process by measuring the acquired knowledge after completing each chapter/learning materials. In this context we proposed a system that allowed the learner to search for the learning materials from different recourses and compose the coursework according to his capability and preferences (difficulty level, price, semantic value). A pretest is assigned to the learner to measure his background knowledge before proceeding to the learning process, and the result of this pretest is saved to the learner's profile in the person ontology. We have proposed a method to compute the score of the test's questions based on knowledge extracting. The semantic keywords that the learner has learned is consider as the knowledge the learner has acquired. We extract the semantic keywords from the question's answer to evaluate the acquired knowledge then we calculate the score for the question's answer as in equation 2:

$$\mathrm{score} = \sum_{i=1}^{n} \mathrm{sv_i} * \frac{1}{1-\log_{tl}\mathrm{frq_i}} * (1 - \log_{tl}|\mathrm{p_i} - \mathrm{cp_i}|) \quad (2)$$

Where sv_i is the semantic value of the semantic keyword i in the ontology, tl is the total length of the answer, p_i is the position of the semantic keywords in the ontology. cp_i is the current position of the semantic keyword in the answer and n is the total number of matches semantic keywords in the answer.

Table 2 Performance evaluation for 4 learners

Learner	Semantic Keyword	First position	Frequency of occurrence	Semantic Value	Frequency weight	Position weight	Score
Learner 1	class	1	5	0.9	1.473197445	1	1.325878
	superclass	2	4	0.8	1.382495573	1	1.105996
	subclasses	3	10	0.7	1.850274154	1	1.295192
	attributes	4	3	0.5	1.280829711	1	0.640415
	behaviour	5	2	0.64	1.160544085	1	0.742748
Score							**9.562615**
Learner 2	class	1	2	0.9	1.160544085	1	1.04449
	superclass	2	7	0.8	1.6349379	1	1.30795
	subclasses	4	3	0.7	1.280829711	0.861664811	0.772552
	attributes	5	1	0.5	1	0.861664811	0.430832
	behaviour	3	2	0.64	1.160544085	0.780743913	0.579896
Score							**7.739047**
Learner 3	class	1	7	0.9	1.6349379	1	1.471444
	superclass	2	3	0.8	1.280829711	1	1.024664
	subclasses	4	4	0.7	1.382495573	0.861664811	0.833873

	attributes	5	7	0.5	1.6349379	0.861664811	0.704384
	behaviour	3	6	0.64	1.556641376	0.780743913	0.777816
Score							**9.004888**
Learner 4	class	1	20	0.9	2.486787	1	2.238109
	superclass	0	0	0.8	1	0	0
	subclasses	0	0	0.7	1	0	0
	attributes	0	0	0.5	1	0	0
	behaviour	0	0	0.64	1	0	0
Score							**4.188104**

We have assumed that the occurrence of semantic keywords in the answer should be in specific sequence. Also we have considered the frequency of occurrence of each semantic keyword in the answer. Each semantic keyword appear in the pretest's answer is consider to be background knowledge and store in the learner's profile as BackgroundConcepts. In table 2 we are showing the normalized score for four learners for the question "What is an Inheritance?" to demonstrate the performance evaluation by knowledge extracting. From table 2 we can observe that answer from learner 1 contains the five semantic keywords and he has written them in his answer in proper sequence. Learner 2 and learner 3 have written the semantic keywords in the same sequence but the length of the answer of learner 3 in longer than the answer from leaner 2. Finally the answer of learner 4 contains only one semantic keywords and his score is low.

The same calculation is used to compute the result of the final test which is assign to the learner after completing each courseware. The result of the final test is stored in the leaner's profile as ConceptLearned. The reasoning rules are used to infer the concept to be learned from the learner's profile in person ontology, the result of these rules is based on the semantic keywords of the background concept and concept leaned. The next courseware will assign to the learner according to his performance and his background, the courseware will be contain the semantic keywords that infer using reasoning.

Representing the E-learning using Semantic web technology by adding annotation to the learning contents will add description to them. Moreover, representing the learning materials and their questions by semantic keywords in the ontology will allow the instructor to assign and mark the description questions for the learner during the learning process. The semantic keywords could be used to evaluate the learner's performance by using reasoning which is one of the features of semantic web.

VI. CONCLUSIONS AND FUTURE WORK

Learner's performance evaluation is one of the most frequent activities in both conventional learning and e-learning systems, representing the E-learning contents in form of ontology by describe the learning materials along with their semantic keywords will allow the semantic access and search for the learning materials. We have used learning materials' ontology to score the description questions and evaluate the learner's performance. The evaluating is based on extracting the semantic keywords which represent acquired knowledge of the contents from the learners' during test and updates the learners' profiles. Reasoning is used to infer the concepts learned and the concepts to be learned by the learner according to the semantic keywords of the concepts. Using reasoning and acquired knowledge extracting we can assign the next courseware to the learner.

Assigning individual course to the learners according to their interest, background knowledge, learning goals, preference and style is applied in some of the e-learning systems, for future work, however, this personality of learning need to provide individual test according to the acquired knowledge by the learner for different test type such as analysis, description and reasoning questions and combination of them.

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