Digital Innovations
& Contemporary Research in
SCIENCE & ENGINEERING
Vol. 5 No. 2, June 2017

Article Citation Format
I.T. Ayorinde & C.N. Iweala (2017). Enhancing Personalization In E-Learning Systems Using Ontology. Journal of Digital Innovations & Contemp Res. In Sc., Eng & Tech. Vol. 5, No. 2. Pp 151-166

Article Progress Time Stamps

Article Type: Research Article
Manuscript Received: 12th May, 2017
Review Type: Blind
Review/Acceptance Information Sent : 14th June, 2016
Final Acceptance:: 15th June, 2017
DOI Prefix: 10.22624

Enhancing Personalization in E-Learning Systems Using Ontology

I.T. Ayorinde & C.N. Iweala
Department of Computer Science
University of Ibadan
Ibadan, Nigeria.
[1]temiayorinde@yahoo.com, [2]iwealachisom@gmail.com)

ABSTRACT
Personalization in e-learning systems using ontology is the next step in the evolution of e-learning systems. It is a means of improving the existing e-learning system so as to satisfy the requirements of different users or learners. From the literature, the problems of the existing e-learning systems include the one size fit all approach to presenting the learning content to users and lack of flexibility among others. Hence, this study develops an enhanced personalized e-learning system based on the users learning style and competency level using a formal ontology. The ontology was built using description logic and implemented with Protégé 2000. The e-learning system was built using PHP which is a server-side scripting language, while MySQL was used for storing and retrieving data that are stored in the database. Fuseki server was used for hosting and querying the ontology. A well structured, efficient and reusable formal ontology was created which was then incorporated into the e-leaning system. The enhanced e-learning system therefore accommodates the different learning styles of the users and their competency levels such that resources given to the student fit his/her need and support him/her during the learning process.

Keywords: Enhanced E-learning System, Personalization, Ontology, Protégé 2000.

1. BACKGROUND TO THE STUDY

Ontology is an explicit formal specification of a conceptualization [1]. Ontologies allow key concepts and terms relevant to a given domain to be identified and defined. Its capacity to represent knowledge, facilitate reasoning and also allow the use and exchange of knowledge between systems or users contributes to the computational intelligence of its system [2]. Thus, ontologies can be used to support knowledge management and to provide some intelligence to e-learning systems. Ontologies can be formalized with the use of representational languages such as first order logic or description logic.

According to [3] & [4], Learning is a process that brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values, and world views [3], [4]. E-Learning is often described as the use of network technology (e.g. the internet) to design, deliver, select, administer and extend learning [5], while learning is the knowledge or skill gained from teaching or study. E-Learning was meant to automate education, replace a paid instructor, and develop self-paced learning [6]. The e-learning goal is to break the barriers of time and space by the automation of learning [7] and it is clear that new ways of learning are some of the next challenges for every industry and educational institution. The increasing use of information and communication technologies in higher education makes most universities offer online services [8] which include an increasing use of e-learning systems to deliver courses. However, existing e-learning systems are very limited in the personalization services they offer to students thereby making the learning process not very efficient [9]. Hence, personalization in e-learning systems using ontology is the next step in the evolution of e-learning systems. It is a method of improving the existing learning system to satisfy the requirements of different users or learners.

Among the variety of modern trends in educational technology development, the application of ontological research is probably one of the most fashioned and rapidly evolving one. Ontology technology is considered to be a highly suitable means of supporting educational-technology systems [10], [11]. It can be used to make the knowledge structure which improves the interaction among teachers and students. It also enables spontaneous learning by students by having the teaching contents and learning materials based on semantic information. It also acts as a formal means to describe the organization of universities, courses and define services in a structure that can facilitate reasoning, use and exchange of knowledge between the components and users of the system and by that, contribute to the increase of its computational intelligence

In the context of e-learning, personalization could be applied to some aspects, which are personalization of learning materials (based of preferences, learning style, educational background, and capabilities), ways and presentation form of learning materials, or the composite of them.

2. RELATED WORKS

There have been many attempts to implement personalized e-learning systems. In recent years, researchers have been mainly focusing on applying semantic web technologies to implement personalized e-learning systems. The following related works show diverse approaches in implementing e-learning systems.

(i) Ontology-based framework for user model interoperability in distributed learning environments [12]. In this work, Advanced Distributed Architecture for personalized e-learning (ADAPT) was created to apply a higher level mechanism for ontology-based interoperability between self-contained adaptive web-based systems. It establishes a general framework for distributed education and it uses original protocols for interactions between various components. The main idea of ADAPT was the use of an ontology server (OS) to user model exchange. The OS stores ontological structures of educational domains to resolve possible conflicts in domain models for specific applications [12]. It acts as a common central storage of user's knowledge for different concepts reported by any user model server. User Model Server stores students' activities and infers their learning characteristics, which form the basis for personalization. ADAPT's architecture allows for multiple OS - as several ontologies even for the same domain are possible.

(ii) Ontology-driven e-learning system based on roles and activities for Thai learning environment (O-DEST) [13]. O-DEST comprises of an ontology for the e-Learning process, such as course syllabus, teaching methods, learning activities and learning styles. O-DEST helps teachers, students and administrative personnel to set up and maintain the course material as well as the course administration. O-DEST provides a unified platform for logging, assessing, planning, delivering content, managing records and reporting [13]. These activities help both the self-paced and instructor-led-learning process. It was designed with three basic modules which are tools for the teachers, tools for the students and tools for the administration. The first tool consists of functions, which helps the teachers in creating learning objects, connecting the objects to existing ones. The second tool enables the students to master the learning material and meet the learning goals of the course. The third tool supports different management functions and tasks of the system. O-DEST has highly structured learning modules, which are transparent and accessible through the web. It does not introduce the automatic allocation of applications.

(iii) Ontology-based semantic recommendation in programming tutoring system [15]. PRogramming TUtoring System (Protus) is a tutoring system for teaching the essence of the Java programming language. The system recommends personalized learning content based on student's learning style [14], [15]. Protus 2.0 is the new version of the original system which performs effective personalization mostly based on the Semantic web technologies. The system relies on the Semantic web standards and technologies, specifically, ontology and adaptation rules for knowledge representation and inference engines for reasoning.

(iv) Building a Fuzzy Knowledge Management System for Personalized e-learning [16]. Building a Fuzzy Knowledge Management System for Personalized e-learning presented Fuzzy Knowledge Management System for personalized learning by considering the factors such as learners' profiles, learning materials and learning strategies [16]. The knowledge base of their system includes course and concepts ontologies, learners' profiles and learning objects knowledge. They applied fuzzy logic techniques to express and process the knowledge.

In contrast to the above related works, this newly enhanced e-learning system automatically allocates contents to the users by making use of a single ontology and by incorporating both the learning style and competency or performance level of the learner in the allocation of courses and materials.

3. MATERIALS AND METHODS

The ontology was built using description logic and implemented with Protégé 2000. The e-learning system was built using PHP which is a server-side scripting language, while MySQL was used for storing and retrieving data that are stored in the database. Fuseki server was used for hosting and querying the ontology.

System Architecture of the E-Learning Ontology

The system is developed in a multi-layered structure as seen in Figure 1.

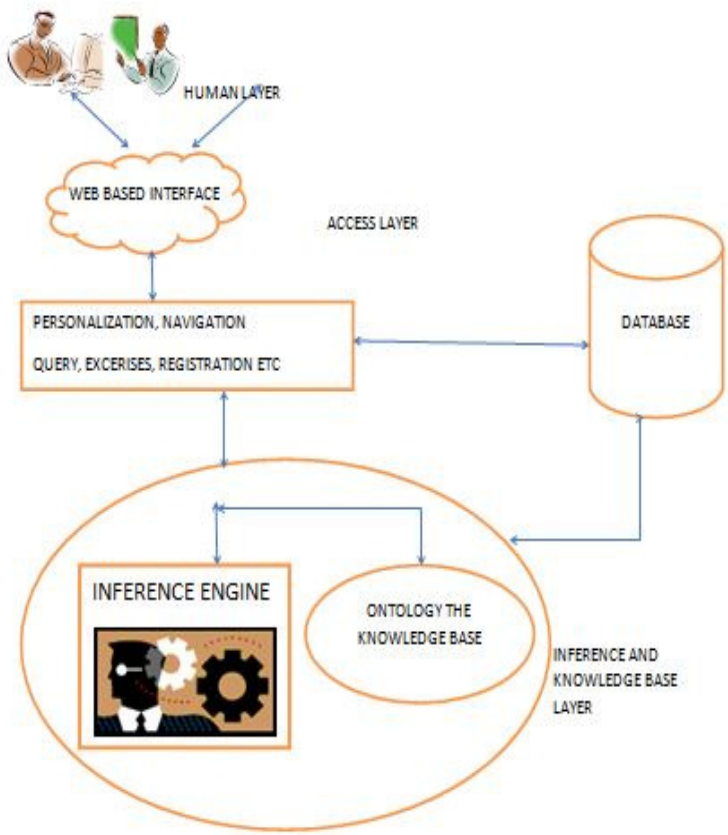

Figure 1: The E-Learning System Architecture

The layers are organized in the following order: knowledge base, inference engine, service layer, access interface and finally the users. The Knowledge base layer is the storehouse of the system. It stores the ontology of the e-learning domain which was created using an ontology editor Protégé and stored in the system knowledge base with some rules which act as nerves of the system. The database is used to store the user profiles and pool of learning resources among others while the inference engine allows the querying of the knowledge base. That is, it reasons and infers new knowledge and new facts from the given knowledge in the knowledge base.

After processing the query, based upon the given facts, it infers the knowledge and sends response to the user through the user interface. The service layer offers different services like personalized search services, querying services, navigation and notification services among others. User and access interface is a common integrated user interface managed by the right controller through which users can navigate the learning materials or access the knowledge base. The human layer consists of the students, the tutors and the administrator.

Figure 2 shows the process of building the ontology. Knowledge elicitation was the first step. This enables one to identify the purpose and scope of the ontology. The various concepts were identified and the classes, instances and their various attributes were defined. Facts, rules and relations between concepts were defined and formalized with description logic. These were tested with various queries, otherwise known as competency questions.

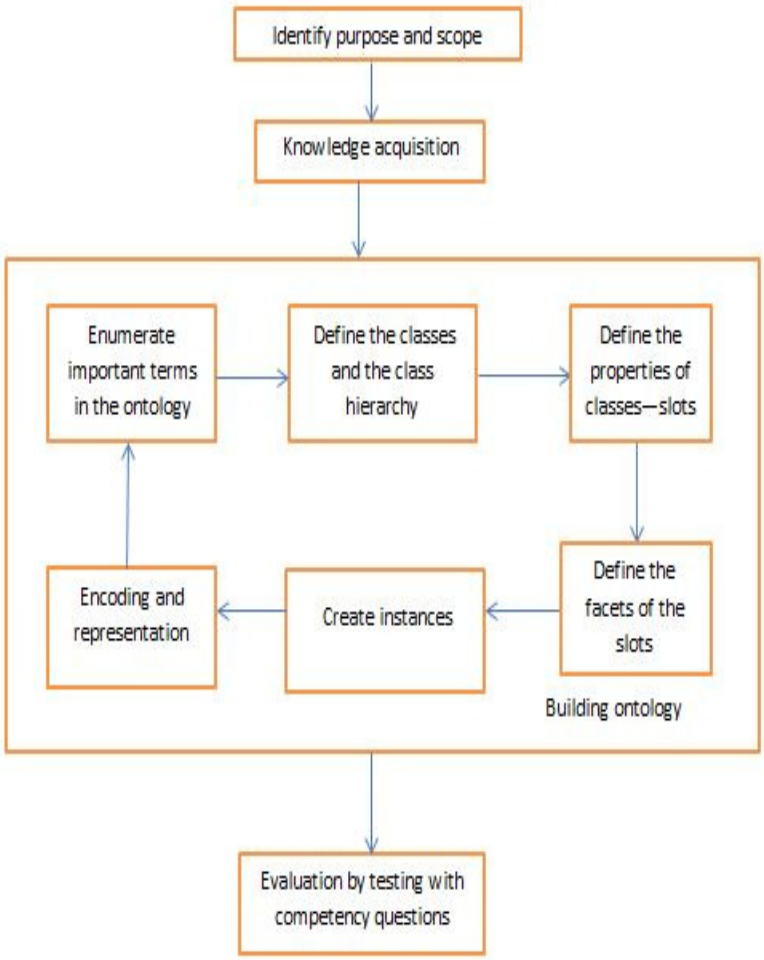

Figure 2: The ontology building life-cycle

The description of the Classes (Courses, Users, Examination, Course materials) are given below:
Class: Courses
Courses: A collection of courses.
Has Subclasses: CSCourses, MTHCourses
Properties Include: hasCourses, CourseID, CoureTitle
Class: users
Users: These are the people who would be using the system. The user class basically deals with the Students and the Teacher classes.
Has Subclasses: learner, tutor
Properties Include: hasSex, age, name, address, email
Class: learner
Learner: This refers to the student taking the courses
Has Instances : Wilson and Laolu among others
Properties Include: age, name, address
Subclass of : User
Class: Tutor
Tutor: This refers to the teacher
Has Instances : Akpan and Ajayi among others
Class: Learning style
Learning style: This refers to student's preference for learning.
Has Subclasses: auditory, visual
Properties**:** It has both object and data properties
i) Object Properties:
hasDone, hasLogin, hasstudenttype, haslearningstyle
ii) Data Properties:
name, address, ID, gender, email, phone, CourseID, CourseTitle

4. FORMALISATION OF THE AXIOMS

Axioms were written for the facts, rules and relations.

1. Axioms for learners' competency level

a. A learner, x, with a competency level of advanced, a, can only be given advanced materials, m_a. (This is a rule)
$Learner(x) \wedge material(m_a) \wedge advanced(a) \wedge hascompetencylevel(x,a) \wedge \equiv hasAbilityToUse(x,m_a)$

b. A learner, x, with a competency level of intermediate, i, can only be given intermediate materials, m_i. (This is a rule)
$Learner(x) \wedge material(m_i) \wedge advanced(a) \wedge hascompetencylevel(x,a) \wedge \equiv hasAbilityToUse(x,m_i)$

c. A learner, x, with a competency level of beginner, b, can only be given intermediate materials, m_b. (This is a rule)
$Learner(x) \wedge material(m_b) \wedge advanced(a) \wedge hascompetencylevel(x,a) \wedge \equiv hasAbilityToUse(x,m_b)$

2. Axioms for assessment and knowledge

In the rule for assessment, a Course is assumed to be known whenever the learner gets a score equal or greater than 50 from the corresponding assessment.

a. For a course y and learner x where the learner took the course, the learner is said to have learnt the course

Course(y) ∧ Learner(x) ∧ took(x, y) ≡ learned(x, y)

b. Once a learner scores below 50 in a course, it implies that the learner failed and cannot move further.

Course (y) ∧ Learner(x) ∧ took(x,y) ∧ Scores(y, v) ∧ LessThan(v, 50.0) ≡ Failed (x, y)

c. Once a learner scores above 50 in a course, it implies that the learner passed the course.

Course (y) ∧ Learner(x) ∧ took(x,y) ∧ Scores(y, v) ∧ GreaterThan (v, 50.0)
≡ Passed (x, y)

3. Axioms for prerequisites

If Course y hasPrerequisite relation with z, it means that the learner must learn Course z before Course y (it is necessary to know Course z for learning Course y). Hence, courses with prerequisites cannot be taken except the prerequisite course has been taken by the student before.

a. A learner can take a course y if s/he has already taken the prerequisite course z.

readyToLearn(x, y) ≡ Course(y) ∧ Course(z) ∧ Learner(x) ∧ hasPrequiste(y, z)
∧ HasPriorKnowledge(x,z)

b. A learner can take a course y if s/he has already taken the prerequisite course z.

¬readyToLearn(x, y) ≡ Course(y) ∧ Course(z) ∧ Learner(x) ∧ hasPrequiste(y, z)
∧ ¬HasPriorKnowledge(x,z)

4.Axioms for Learning Style

People learn differently, thus the idea of considering individual differences are valuable in order to improve learning outcome.

a. Learner(x) ∧ Material(m) ∧ LearningStyle(d) ∧ Visual(d) ∧ supports(y, d) ∧ hasLearningStyle(x, d), ≡ isgiven(x, m)

This rule states that a learner with a learning style of visual should be given only visual materials.

b. Learner(x) ∧ Material(l) ∧ LearningStyle(e) ∧ Audio(e) ∧ supports(l, e) ∧ hasLearningStyle(x, e), ≡ isgiven(x, l)

This rule states that a learner with a learning style of audio should be given only audio materials.

. Learner(x) ∧ Material(n) ∧ LearningStyle(g) ∧ Reading(g) ∧ supports(n, g) ∧ hasLearningStyle(x, g), ≡ isgiven(x, n)

This rule states that a learner with a learning style of reading should be given only reading materials.

Other Axioms (Facts)

1. User ⊆ learner ∨ Tutor
   A user can either be learner or a tutor.
2. Learner ∧ Learning style
   A learner must have a learning style
3. Learner ∧ competence level
   A learner must have a competence level
4. login(user)
   All users must have a security login

5. IMPLEMENTATION AND RESULTS

Protégé Implementation

Figures 3, 4 and 5 show the classes, data properties and object properties used for the e-learning ontology.

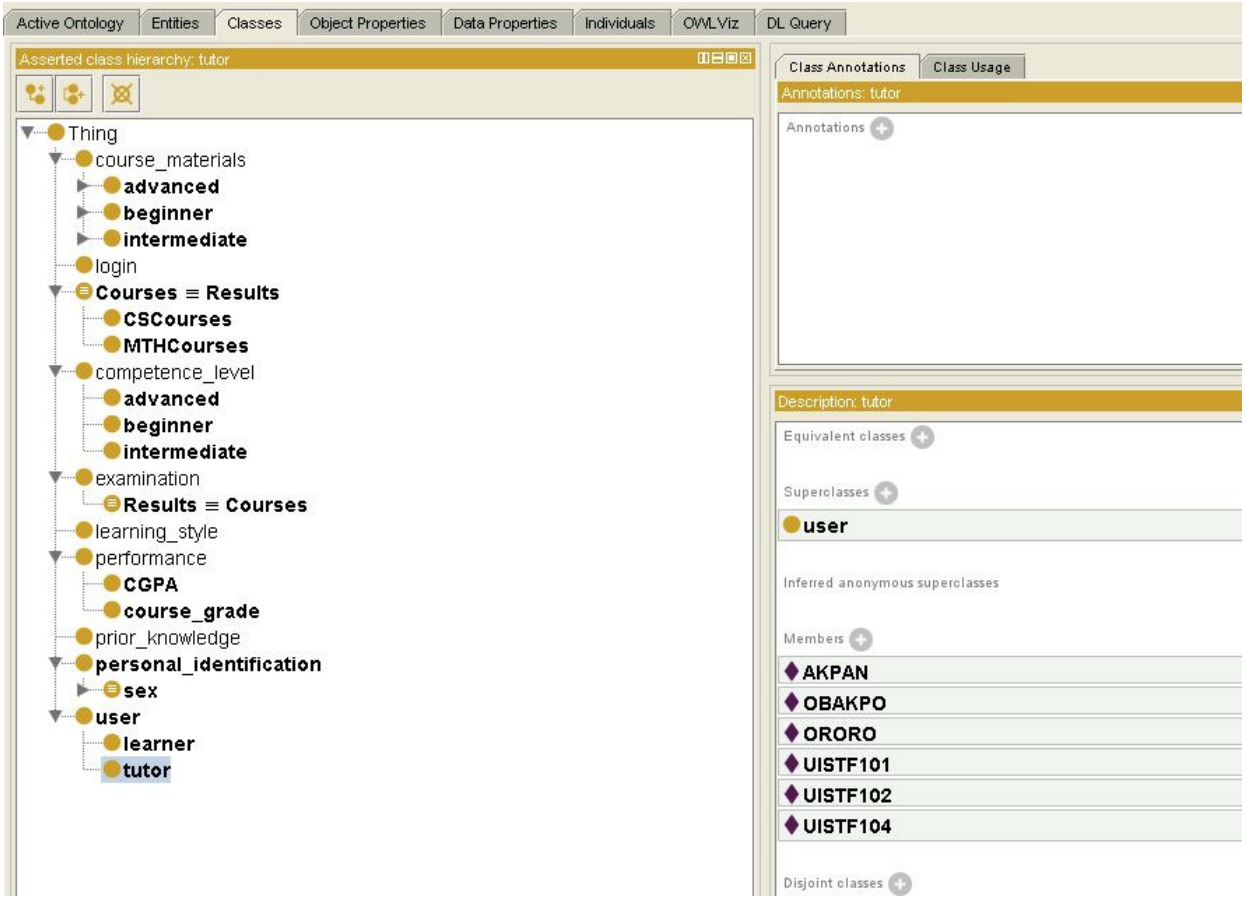

Figure 3: The e-learning class

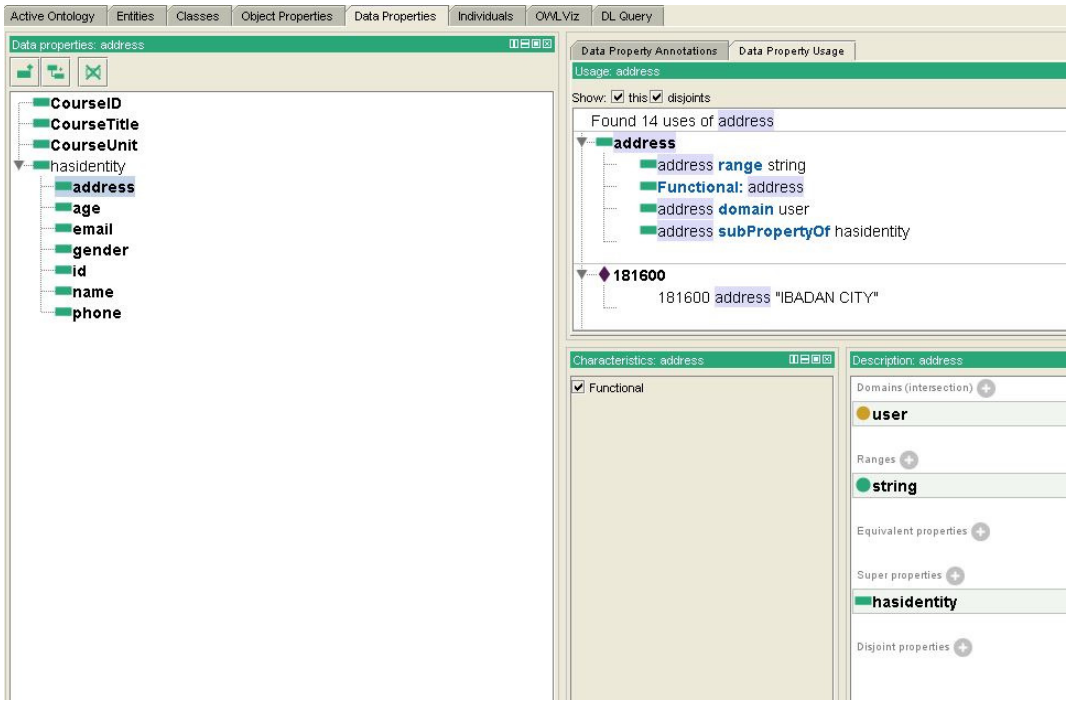

Figure 4: The e-learning data properties

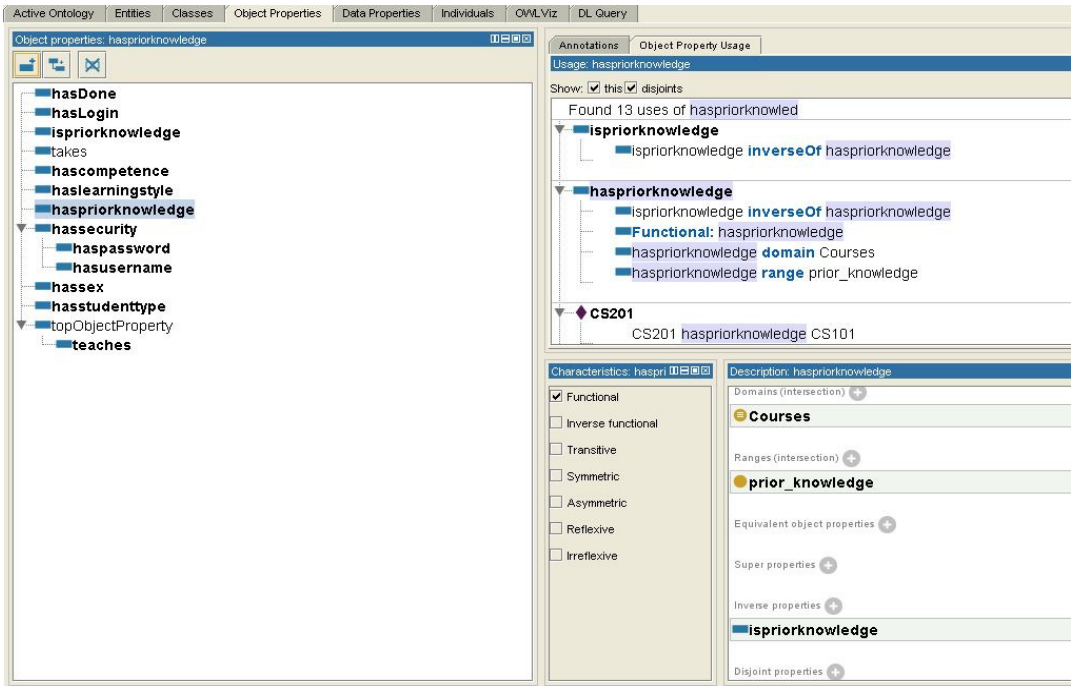

Figure 5: Object properties of the e-learning system

Figures 6, 7 and 8 show the ontograph of the classes and the concepts in the ontology

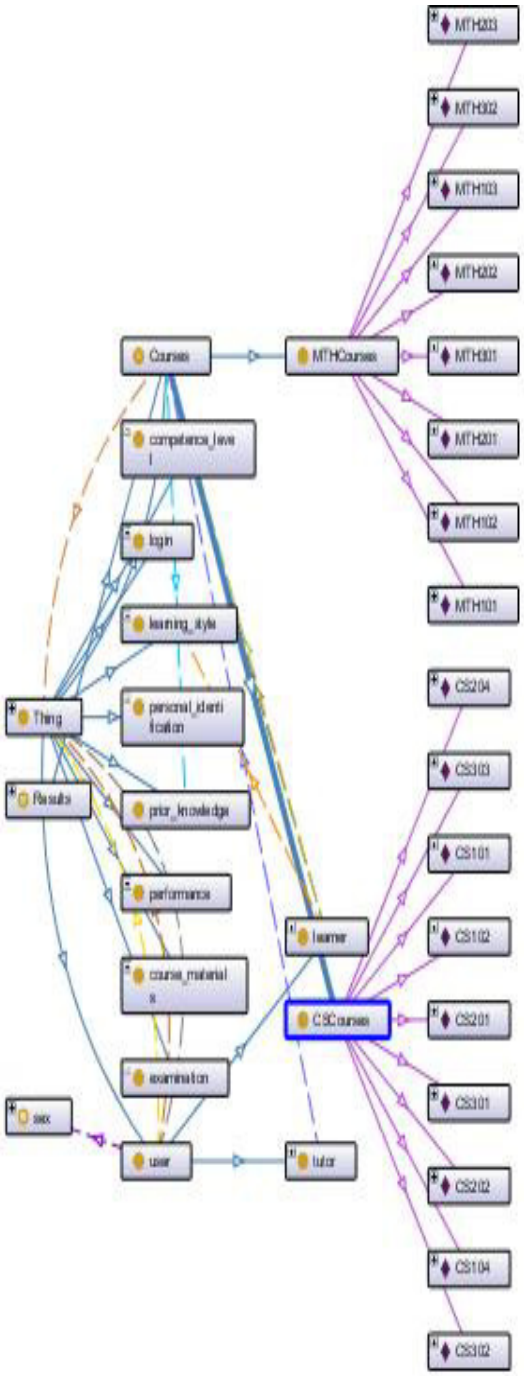

Figure 6: Graph showing the available courses

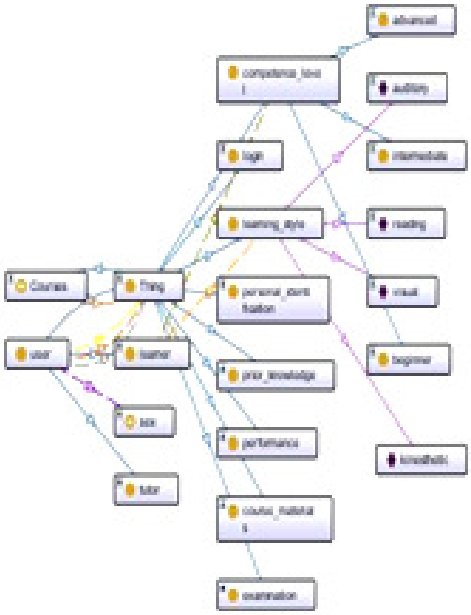

Figure 7: Graph showing the competency level and learning style class with their sub classes.

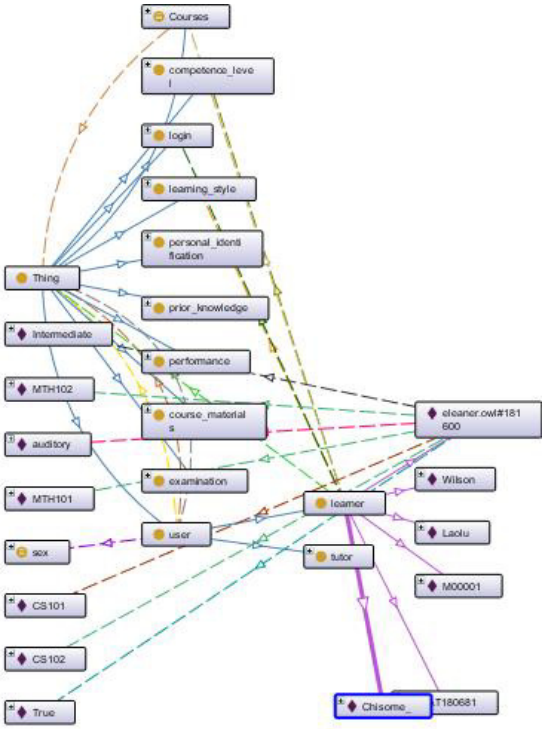

Figure 8: Graph showing the learner class and its instances

Figures 9 - 12 show the various interfaces for the enhanced personalized e=learning system.

Figure 9: The registration interface

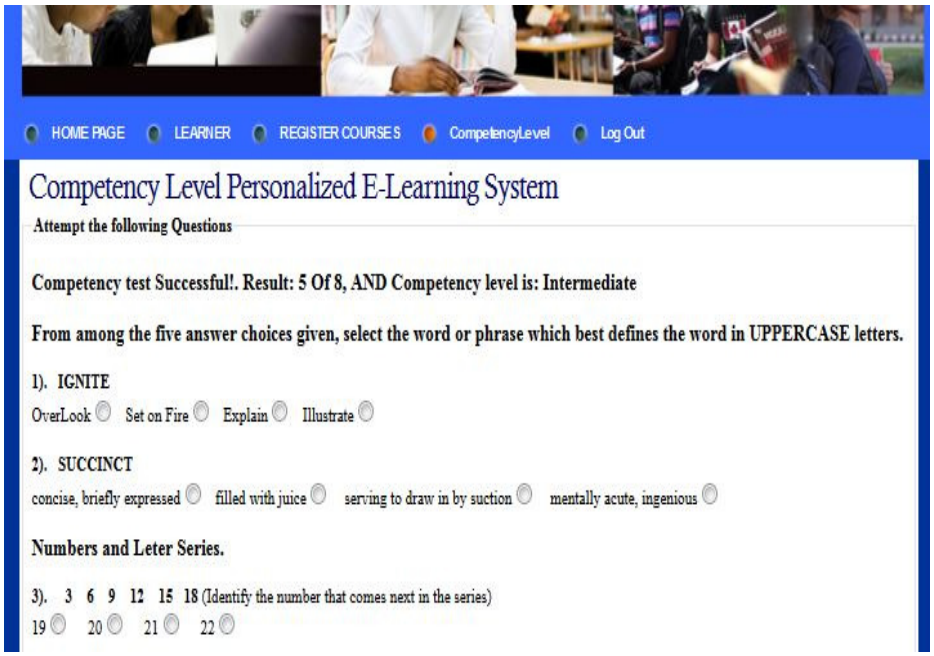

Figure 10: The interface where the system determines the learner's competency level after the registration interface

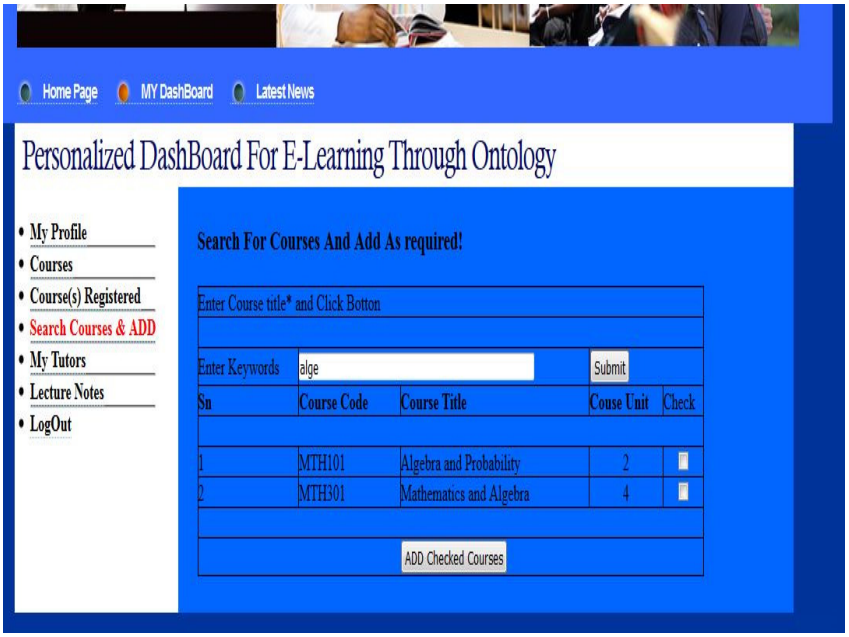

Figure 11: The e-learning system (search and add course view)

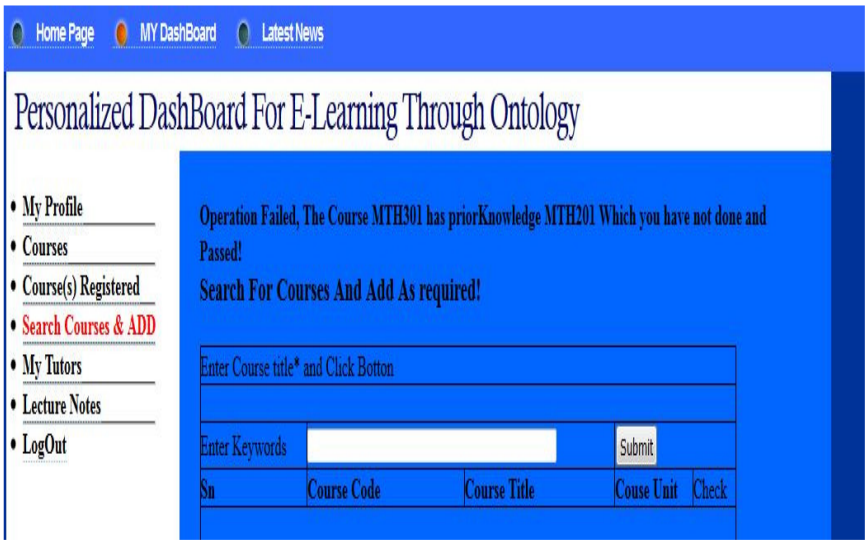

Figure 12: This interface refuses a learner from taking a course if s/he has not taken the prerequisite course

Figure 13 displays the result of a query using sparql to select from the ontology where CS102 exists.

```
5   pre:CS102?p ?o
6 }
7 LIMIT 25
```

QUERY RESULTS

Raw Response | Table

Search: Show 50 entries

	s	p	o
1		<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://www.w3.org/2002/07/owl#NamedIndividual>
2		<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://www.semanticweb.org/user/ontologies/2015/11/Ontology1449645998975.owl#CSCourses>
3		pre:CourseUnit	2
4		pre:CourseID	"CS102"
5		pre:CourseTitle	"Data Structures1"
6		pre:ispriorknowledge	pre:CS202

Showing 1 to 6 of 6 entries

Figure 13: Sparql to select CS102

6. CONCLUSION

The enhanced personalization e-learning ontology developed in this study identifies the actual requirements of learner. It allows necessary materials to be presented in various formats for each specific user thereby accommodating different learning styles such that auditory learners could benefit from audio, visual learners could benefit from visual materials and reading learners could benefit from written materials. The learning resources are accompanied by machine-readable descriptions which makes them easily retrievable during search such that only relevant resources are provided to the users. The discovery, identification, categorization and presentation of relevant results are all performed by the system and not the human.

7. FUTURE WORK

One of the possible areas of future work is facilitating personalized e-learning system that involves communication between students who collaborate towards reaching common objectives. Personalized collaborated e-learning is one of the most meaningful ways to support individual learning whereby the learner model could help the system select learners with similar learning styles in a group so they could better understand themselves and achieve common goals.

REFERENCES

[1] T. R. Gruber, "A Translation Approach to Portable Ontology Specifications", *Knowledge Acquisition* 5 (2): 1993, pp199-220.

[2] J.Sarraipaa and R. Jardim-Goncalves, "Semantics Adaptability for Systems Interoperability", In Proceedings of the 1st UNITE Doctoral Symposium, 27-28 June 2011, Bucharest, Romania

[3] K. Illeris, "A model for learning in working life", *Journal of Workplace Learning, 16*(8), 2004, pp 431–441. doi:10.1108/13665620410566405

[4] J. Ormrod, "Educational Psychology: Principles and Applications" Englewood Cliffs, NJ: Prentice-Hall. 1995

[5] M. S. Hamdi, "Masacad: A multi-agent approach to information customization for the purpose of academic advising of students", *Applied Soft Computing 7(3),* 2007, pp. 746 – 771.

[6] S. Ljiljana, S. Staab and S. Rudi, "eLearning based on the SemanticWeb" , *FZI Research Center for Information Technologies at the University of Karlsruhe, 76131 Karlsruhe, Germany.* 2001.

[7] V. R. Pandit, "E-Learning System Based on Semantic Web", *International Conference on Emerging Trends on Engineering and Technology,* IEEE computer society. 2010.

[8] S. Kurt, "The accessibility of university web sites: the case of Turkish universities", *Universal Access in the Information Society, Vol 10,* 2011, pp. 101-110.

[9] S. E. Peter, E. Bacon and M. Dastbaz, "Adaptable, personalised e-learning incorporating learning styles", *Campus Wide Information Systems, vol 27*, 2010, pp. 91-100.

[10] D.G. Sampson, M. D. Lytras, G. Wagner, and P. Diaz, "Ontologies and the Semantic Web for E-learning", *Journal of Educational Technology and Society 7(4),* 2004, IEEE.

[11] L. Aroyo, D. Dicheva, and A. Cristea, "Ontological Support for Web Courseware Authoring", *Proceeding Conference on Intelligent Tutoring Systems ITS 2002,* pp. 270-280.

[12] P. Brusilovsky, S. Sosnovsky, and M. Yudelson, M., "Ontology-based framework for user model interoperability in distributed learning environments", *in* 'Proceedings of World Conference on ELearning (E-Learn 2005)', Vancouver, Canada, pp. 2851–2855.

[13] C. Snae, and M. Brueckner, M., 'Ontology-driven e-learning system based on roles and activities for thai learning environment', *Interdisciplinary Journal of E-Learning and Learning Objects* 3, 2007, pp. 1–17.

[14] B. Vesin, M. Ivanovic, A. K. Milicevic and Z. Budimac, 'Protus 2.0: Ontology- based semantic recommendation in programming tutoring system', *Expert Syst. Appl.* 39(15), 2012, pp. 12229–12246.

[15] B. Vesin, M. Ivanovic, A. Klasnja-Milicevic and Z. Budimac, "Rule-based reasoning for altering pattern navigation in programming tutoring system", *in* 'System Theory, Control, and Computing (ICSTCC), 2011 15th International Conference on', Sinaia, pp. 1 –6.

[16] M. A. Salahli, M. Ozdemir, C. Yasar, "Building a Fuzzy Knowledge Management System for Personalized E-learning, Procedia - Social and Behavioral Sciences, Volume 46, 2012, Pages 1978-1982, ISSN 1877-0428, 10.1016/j.sbspro.2012.05.414