Implementing Ontology for E-learning System Development In Indonesia based on Web 2.0

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ABSTRACT: *Website is a tangible result from the existence of Internet technology. Based on the trends, the web technology utilization has evolved. The initial version of the Web technology– Web 1.0, only serves the needs for information searching and browsing. Today, the Web technology has evolved into its second generation - Web 2.0, which comes with better features for information sharing and interactions in the forms of document sharing, picture sharing, video sharing, Wikis, and online networking. All these new forms of Web technology relies on the power of online communities.*

The development of the Web technology allows "anywhere-anytime" teaching and learning interactions, which we call electronic learning (e-learning). E-learning needs self-learning habits as well as personal motivation to learn. Unfortunately, Indonesian students, in general, are still weak in those two important factors. It is even worse as the current e-learning system in Indonesia only accommodates the same learning material delivery method to all students. Consequently, it ignores the cognitive aspects and interactive self-learning approach based on the users characteristics. The Web 2.0 technology opens up the possibility to repower the Indonesian e-learning system with better interactions and personalization, which may attract students to play more active learning role within the e-learning system. It is due to the Web 2.0's capability to personalize the learning experience using e-learning to students' understanding capacity and learning adaptation capability, as well as the possibility for better organization of supportive learning resources.

In this research, the proposed e-learning system utilizes ontology as the representation of meaning of knowledge formed by the students' users.

Keywords: e-learning, personalized e-learning, adaptive e-learning, ontology

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1. Introduction

Today, Internet technology utilization in the well-developed countries as well as developing, countries such as Indonesia has increased significantly, changing our way of life. According to World, by 2008, there are 20 million Internet users in Indonesia, the fourteenth in rank after Canada [1]. Internet has also changed the place and location paradigm as it eliminates distance of communication. The utilization of Internet is especially powerful for Indonesian as an archipelagic country.

Website is a tangible result from the existence of Internet technology. Based on the trends, the web technology utilization has evolved. The initial version of the Web technology – Web 1.0, only serves the needs for information searching and browsing. Today, the Web technology has evolved into its second generation - Web 2.0, which comes with better features for information sharing and interactions in the forms of document sharing, picture sharing, video sharing, Wikis, and online networking. Examples are slideshare, Flickr, YouTube, Wikipedia, weblog, and web forums. All these new forms of Web

technology relies on the power of online communities. In the education world, we recognize a form of Web technology used for learning purposes – e-learning, which allows "anywhere-anytime" learning interactions.

The development of e-learning has attracted attention from both the education and business communities. In the business communities, e-learning has helped them improved the employees' competencies. As an example, Mandiri Bank in Indonesia has created a Learning Management System (LMS) to train approximately 18,000 employees who work in their 700 branch offices [2]. CISCO, PT. SAP Indonesia, PT. Telekomunikasi Indonesia, and IBM Indonesia have also implemented e-learning to develop their human resources [3]. In the education communities, e-learning has brought changes on their teaching and learning processes. Based on the American Society of Training and Development (ASTD), in 2004, there are 90% of American universities with over 10,000 students, and 60% of the business enterprises that utilize e-learning[4].

As a simplification, e-learning in education is a teaching and learning process by means of personal computers connected by the Internet network. It means that some applications replace all the common teaching and learning tangible facilities. Students can download learning materials in the form of electronic files, while the student-teacher interactions happen in the form of virtual discussions or video conferences.

In Indonesia, the government regulation, such as government law No. 20/2003 about National Education System and the Decree of Education Ministry No. 107/U/2001 about distance learning education, play an important role to fulfill e-learning integration in the education process. Those two regulations set permits for Indonesian higher education institutions to conduct distance learning education using information technology. Along with the e-learning development, there are growing numbers of system development vendors that utilize the open-source technology to develop e-learning systems. The low investment costs, in comparison to the conventional learning system – both hardware and software, drove the rapid growth of the open-source e-learning system. The trend of using the open-source e-learning system in the developing countries is more evident in comparison to the growth of the proprietary e-learning systems. Examples of e-learning developed based on open-source technology are Moodle, Dokeos, and Sakai, while the proprietary e-learning are Blackboard and Web CT.

Although recently there are rapid development of e-learning system, there is no e-learning system that could guarantee the success of learning process transformation and learning implementation. Based on a study by Forrester Group in 2000, there are 68% who reject the use of e-learning for conducting training. Meanwhile, there was another study indicated that of the 50-80% of the users enrolled in e-learning based program never completed the program [5]. The utilization of e-learning system in Indonesia depicts similar problem. Even worse, many e-learning systems in Indonesia died and discontinued from its use.

E-learning needs self-learning habits, as well as, personal motivation to learn. Unfortunately, Indonesian students, in general, are still low in those two important factors. It is even worse as the current e-learning system in Indonesia only accommodates the same learning material delivery method to all students. Consequently, it ignores the cognitive aspects and interactive self-learning approach based on the users characteristics. To gain success for e-learning, Indonesian education institutions need e-learning systems that can stimulate their students to play an active role and provide better interactions and personalization, which may attract students to play more active learning role within the e-learning system.

The existence of Web 2.0 technology (such as Wikis, Blogs, Flickr, and YouTube). can facilitate e-learning systems , which utilize the community contribution. Students can contribute learning content to the e-learning systems using the Web 2.0 technology; then, the meta data can be organized using the ontology.

Ontology, as a knowledge representation in a knowledge base, can be utilized as part of the pedagogical methods for system users in a social network. At the end, with ontology, the e-learning system emphasizes a personalization, which can maintain the students' cognitive level and adjust to students' level of understanding, to improve students' learning motivation.

2. E-learning and Content

Electronic learning or e-learning is a self-governing learning process which is facilitated and supported by Information and Communication Technology [6]. Among the already developed e-learning systems, we can identify two categories based on its interactivity feature:

- Static e-learning. Students can only download the learning contents they need. Administrators can only upload files for the content such as HTML, PowerPoint, PDF, or video files. This system does not facilitate interactive communication and interactive learning environment. In any case, this system is still useful for students who learn independently from various contents posted in the system. In general, this system, although limited, can still support the traditional teaching learning activities in the physical classroom.

- Dynamic e-learning. There are varieties of facilities available in this category of system. There are facilities such as discussion forum, chatting, e-mail, learning evaluation tools, and electronic content management. Students can learn independently outside of the traditional classroom with similar environment in comparison to the physical classroom. Additionally, this system can help to transform teacher-centered learning to student-centered learning processes as students can contribute by learning materials and actively participate in discussions on the materials they have not understood. Therefore, students are better trained to use critical thinking, collaborative learning, and even problem-learning depending on how the instructors set them up in the e-learning system.

The following tables compare the facilities we use based on the time and place (adopted from Distance Learning and Sun Microsystems [6]

	Same Time (Synchronous) (Waktu yang sama)	Different Time (Asynchronous) (Waktu yang berbeda)
Same Place (Tempat yang sama)	Classroom	Learning Center Laboratory Library
Different Place (Tempat yang berbeda)	Audioconferencing Videoconferencing Satellite delivery Chating Room Instrutor-led (Synchronous Learning Systems) Synchronous Streaming	WWW E-Learning Systems Video tape/audio tape CD-ROM Archived Streamed Video Email/Listserv

Table 1. Distance learning comparison

E-learning content is any digital resource that supports learning process. We can categorize e-learning content into two types:

- Textual. Includes text-based content such as plain texts and PDFs.
- Non-textual. Includes multimedia content such as audio, visual, and animation.

The textual contents are easily searchable from search engines by typing in their keywords. However, only those who are familiar with the contents can find the right textual content and combine the contents as they need. On the contrary, it is relatively more difficult to search the non-textual contents using the same method.

Personalization is the next phase of the e-learning evolution. According to Paulo Gomez and his colleagues (2006), learners can indicate different cognitive styles and improve the efficiency in utilizing the e-learning system based on their own preference and utilization level. There are two types of personalization: on-line personalization and off-line personalization. Figure 1 shows on-line personalization – monitoring student interactions in the system continuously and in real-time, and accordingly provide the appropriate content [7].

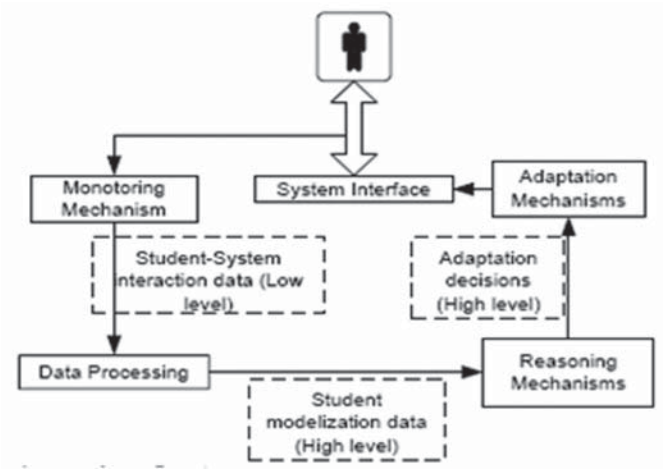


Figure 1. On-line personalization model

Figure 2 shows off-line personalization – available student's data are combined to be analyzed in order to obtain the course content modification.

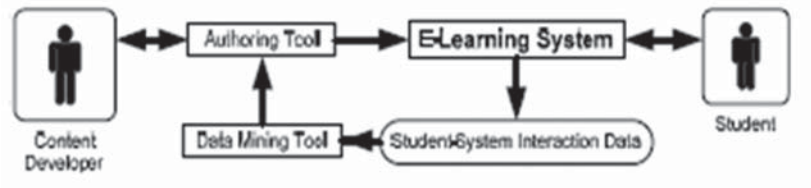


Figure 2. Off-line personalization model

With the emergence of Web Semantic technology, we can add meta data to the e-learning contents (including the pedagogic attributes) and organize these data into ontology to simplify and improve the dispersion, discovery, and utilization of contents. In order to make use of this technology, we need the intelligent agent. The intelligent agent will find and organize content from the heterogeneous content source and combine them as a customized courseware with specific criteria and other specifications. This customized software will constantly refer to the heterogeneous contents are interrelated, while the pedagogic rules will be sustained [8].

3. E-learning Standardization

There are e-learning standards as references during the system development stages [9]

- **LTSC (*Learning Technology Standards Committee*)**

Established by the Institute of Electrical and Electronic Engineers (IEEE) that established many technology standards for electrical, information technology, and science. The goal of LTSC is to establish technical standards accreditation, to give training recommendation, and to model the learning technology.

- **IMS (*Instructional Managements Systems*)**

IMS is an important and well-respected organization in the e-learning community among the academic consortium, business, and government. This organization builds and supports open specification for learning distribution, content development, and students exchange among different systems.

- **ADL (*Advanced Distributed Learning*)**

ADL creates Shareable Courseware Object Reference Model (SCORM). SCORM is a standard of specifications for reusability and interoperability from learning content[10]. SCORM focuses on two most important aspects for interoperability of learning content:

- Define the aggregate model to present learning content
- Define API which can be used for learning contents to communicate with the system.

SCORM also differentiate learning technology based on its functional components:

- Learning Management Systems (LMS)
- Shareable Content Object (SCOs)

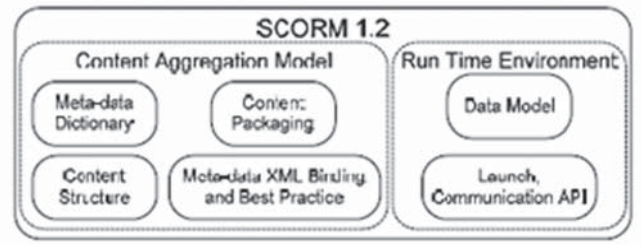


Figure 3. Components of SCORM 1.2

There are various tools that can be used to utilize SCORM such as eXe-Learning.

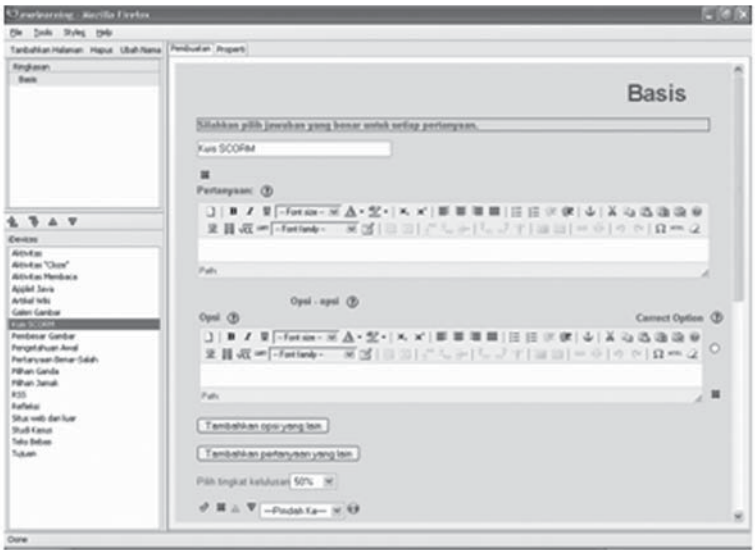


Figure 4. Utilization of SCORM in eXe-Learning

The use of SCORM also supports e-learning such as the open source e-learning system Moodle.

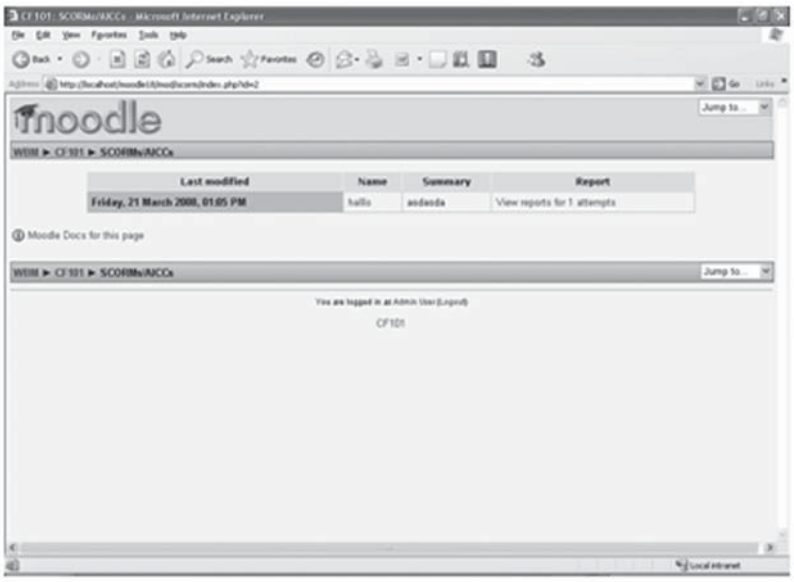


Figure 5. Implementation of SCORM in Moodle

3.1. Semantic Web Technology

Semantic web is further development of web generation as the evolution of World Wide Web (WWW), initiated in 2002 [11]. It is defined as a group of technology that enabled computers to understand metadata-based information – the data of what information contains. With the existence of metadata, computer can interpret the input command to execute better search attempts in more detail and accurate. W3C (World Wide Web Consortium) defines the metadata format as Resource Description Format (RDF). Every RDF unit is composed of 3 parts– subject, predicate, and object. The subject and object is an entity presented by texts. The predicate is the composition that explains the subjective perspectives of the object. The most

interesting feature of RDF is that the object can be transformed into a subject, and explained by other objects. This object becomes an input that can be explained clearly and in detail, according to the users who requested the information.

In order to achieve its objective, there is a need to give an attribute to each of the content in the several layers of semantic web technology (Figure 6).

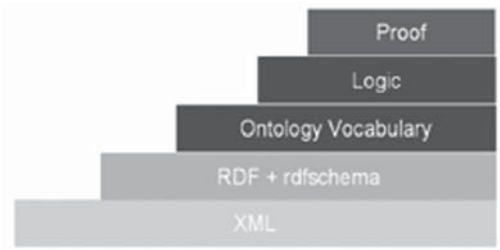


Figure 6. Semantic Web Layers[12]

- XML Layer, representing data
- RDF layer, representing the meaning of the data
- Ontology layer, representing general rule/agreement of the meaning of the data
- Logic layer, implementing intelligent reasoning with meaningful data

Semantic web technology can be used to develop system by collecting e-learning contents from different sources. Then, it processes, organizes, and shares them to the users or artificial agents by means of ontology. There are three important technologies that are required in the utilization of semantic web: eXtensible Markup Language (XML), Resource Description Framework (RDF), and Ontology Web Language (OWL).

3.2. Ontology Web

Ontology has many different interpretations from different perspectives. Neches and his colleagues give preliminary definition about ontology: An ontology is a definition from a basic understanding and vocabulary relation of an area as a rule from terminology combination and relation to define vocabulary [13].

Gruber's definition that is mostly used by people is, "Ontology is an explicit specification of conceptualism."[14].

Barnaras, on CACTUS project, defines ontology based on its development. The definition is, "ontology gives understanding for explicit explanation of concept toward knowledge representation on a knowledge base" [15].

1. A branch of metaphysics that focused on nature and relationships among living creatures;
2. Theory is a natural characteristic of living creatures.

Ontology is a theory about the meaning of an object, property of an object, and the relationship between objects that might be formed. In philosophical perspectives, ontology is a study about something that exists. Additionally, ontology is a concept that systematically explains everything that exists and tangible.

In the Artificial Intelligence disciplines, ontology has two interrelated meanings. First, ontology represents vocabularies targeted on a specific domain or subject. Second, it is a body of knowledge to explain a certain phenomena. In general, Artificial Intelligence (AI) and knowledge presentations utilize ontology. All science in the world can use ontology method to connect to communicate and exchange information among different systems.

To optimize its utilization, a real term needs to express ontology. Ontology language is a formal language from an ontology development. The structure of ontology comprises several components:

- XML provides syntax for structured document output, but it is not required that XML uses semantic constraints.
- XML Language Schema to limit the structure of an XML document.
- RDF model data, for object (resources) and interrelationships among objects, provides simple semantic for the model data. This model data can later be presented in the XML syntax.
- RDF Schema is a vocabulary to explain the properties and classes from a RDF resource, complete with hierarchical semantic of the properties and classes.

- OWL added vocabularies to explain properties and classes, such as: relationship among classes (e.g. disjointness), cardinalities (e.g. on time), equality, variations of properties, characteristic of properties (e.g. symmetry), and specification of each class.

As described, various languages that form ontology have their own place in the ontology structure. Each layer will have additional functionality and additional complexity from the previous layer. Users who sit in the lowest layer, although partially, can understand the ontology of the layer one level above it (Moreale & Vargas-Vera, 2004).

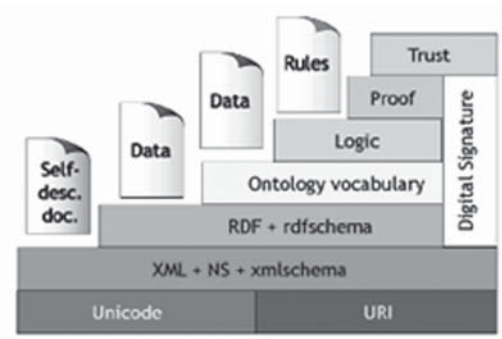


Figure 7. Ontology Layers[12]

In each layer (Figure 7), there are specific functions:

- XML functions as the web page storage
- RDF represents semantics of the web page contents
- Ontology layer explains vocabularies from the domain
- Logic layer allows users to retrieve data as requested

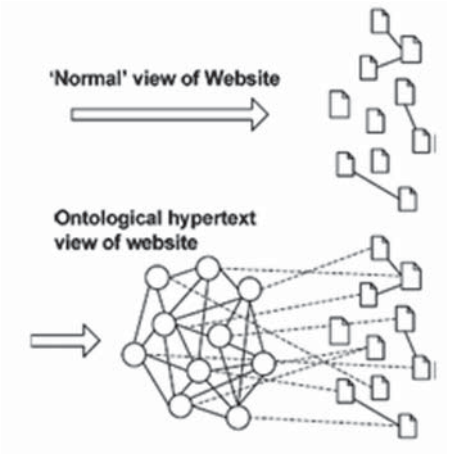


Figure 8. Web Organization Based on Ontology[16]

3.3. OntoEdu

In OntoEdu, ontology describes concept of communication and relationships among education platforms. OntoEdu involves two types of ontology: content ontology and activity ontology [17].

Educational ontology is the main module to organize other components. With ontology, OntoEdu can learn knowledge from education specialist and information specialists. Then, automatically, it will form a content that has been tailored to the users' requests.

Based on ontology and web semantic technology, a flexible educational relationship architecture platform emerged – the OntoEdu architecture. There are five components of OntoEdu [17].

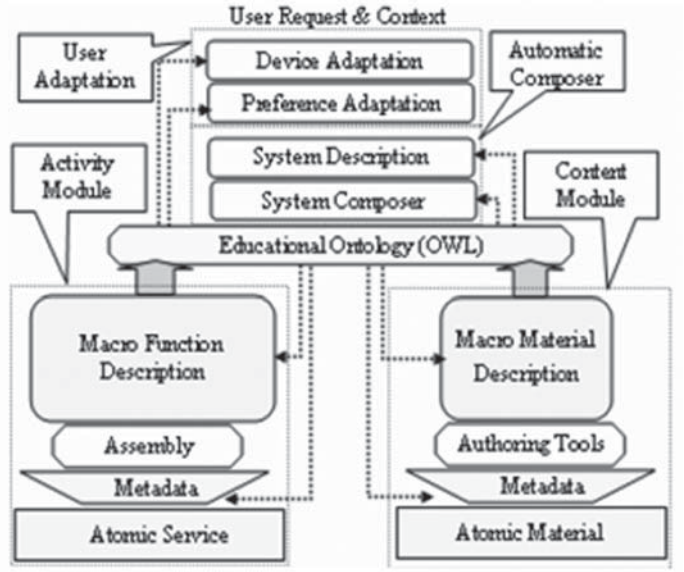


Figure 9. OntoEdu Layers

- User adaptation: Receiving user parameters related to adaptation transformation on a system
- Auto composition: Responsible for distributing tasks according to user's response
- Education Ontology: Involves activity and material ontology
- Service Module: Dynamic model used to improve learning distribution
- Content Module: Dynamic model used to improve content learning distribution

4. E-Learning System Design

Intelligent agent or intelligence-based agents development in a personalized e-learning system play an important role in the e-learning evolution. The agent possesses the capability to perform a task/duty for others. Consequently, the intelligent agent has a task to analyze profile, knowledge quality, and learning capacity in the personalized e-learning system.

The intelligent agent embedded in the e-learning system analyzes available learning models. Thus, we call it as an intelligent tutoring system. The intelligent tutoring system implements learning strategy pedagogically by explaining the content ranks,

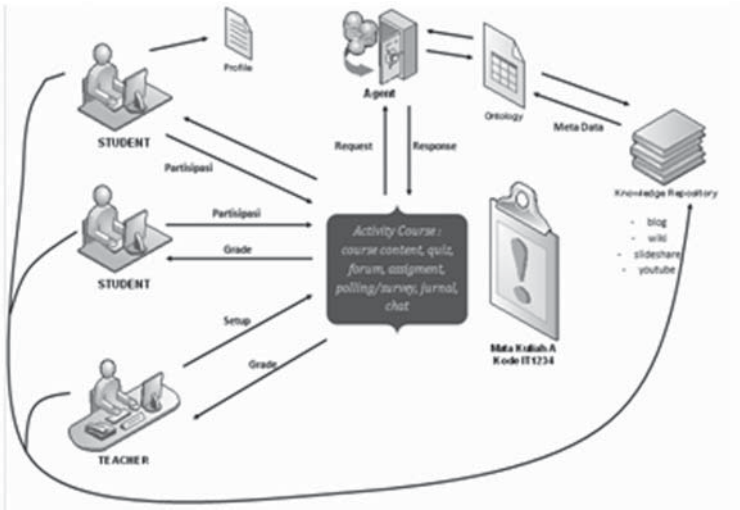


Figure 10. Personalization of E-learning Framework

types of feedbacks received, and how the materials are taught or explained. The agent organizes knowledge resources from Web 2.0 technology in the knowledge repository and representation into the system built based on the ontology for students and instructors.

The e-learning system design implementation Asynchronous, which includes course content, discussion forum, mailing list, and emails. Additionally, it will continue to be synchronous, which includes quiz, chatting, and video-conferencing. Next, ontology-based agent will develop tags and folksonomy to organize knowledge resources based on Web 2.0 technology as shown in Figure 11, such as Wikis, Flickr, and YouTube, which can support course content in the e-learning system.

Figure 11. Knowledge Resources Web 2.0

To support the personalization for the e-learning users, users can customize their e-learning interface for both; their self-collected resources and system-suggested resources. An intelligent agent organizes the knowledge resources by means of ontology to represents the knowledge (Figure 12).

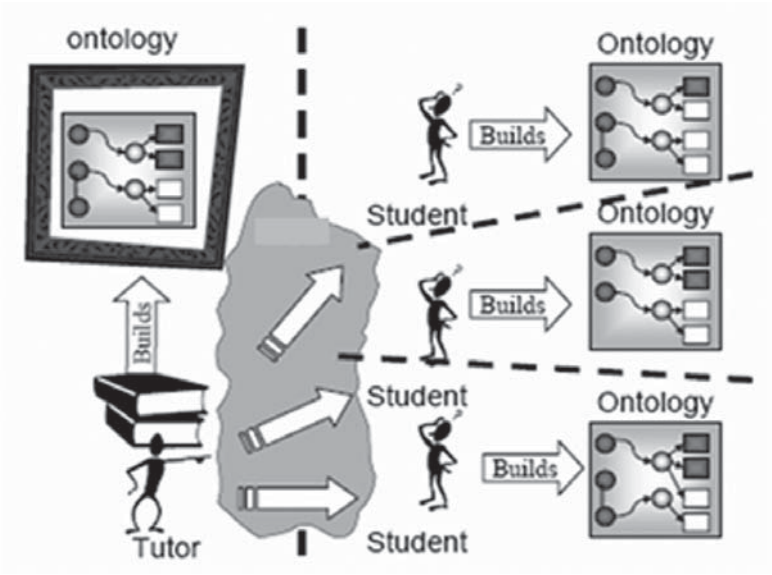


Figure 12. Ontology Results of Knowledge Representation

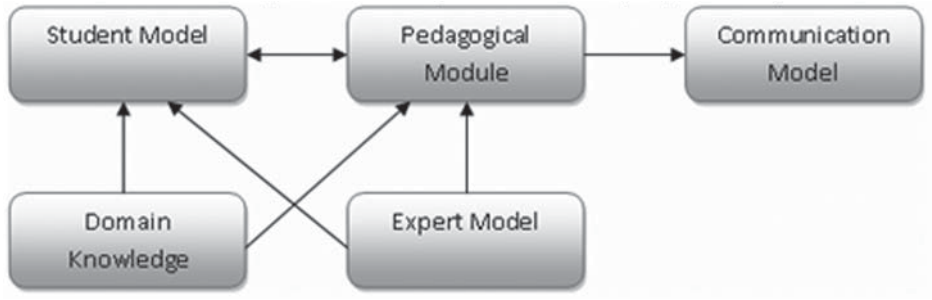


Figure 13. Main Concepts of Intelligent Learning System

The established e-learning system implements five main concepts from the Intelligent Learning System: student model, pedagogical module, communication model, domain knowledge, and expert model (Figure 13).

In the pedagogical module, the best performance is achieved when there is a teacher agent character that knows the learning capability level and can provide motivation, such as feedbacks to the e-learning users and instructors who manage the course.

4.1. Ontology Design

The following is a prototype of e-learning system using ontology in education, specifically in teaching. In the development of this ontology, the first step includes searching and browsing the web, performing categorization on the materials found, identifying, and defining the main concept and metadata content [8]. The results of the categorization produce concept domains for ontology as follows:

- Courses: identify courses with syllabus, notes, and course works.
- Teaching materials: include tutorial (a document defines assignments in a detailed manner), lectures (lecture notes or slides in various formats), lab materials, books (online books), tools (ready-to-use software), code samples, work examples, and white papers.
- Assessments: include quizzes (short questions and short answers), multiple choice questions, open-ended exam tests, or other types of tests.
- Support materials: include collections (from various sources such as homepages and portals), background readings, forum, and other supporting resources to support learning.
- Experts: identify expert teaching communities.
- Institutions: includes instructors, experts' resources, and higher education institutions.

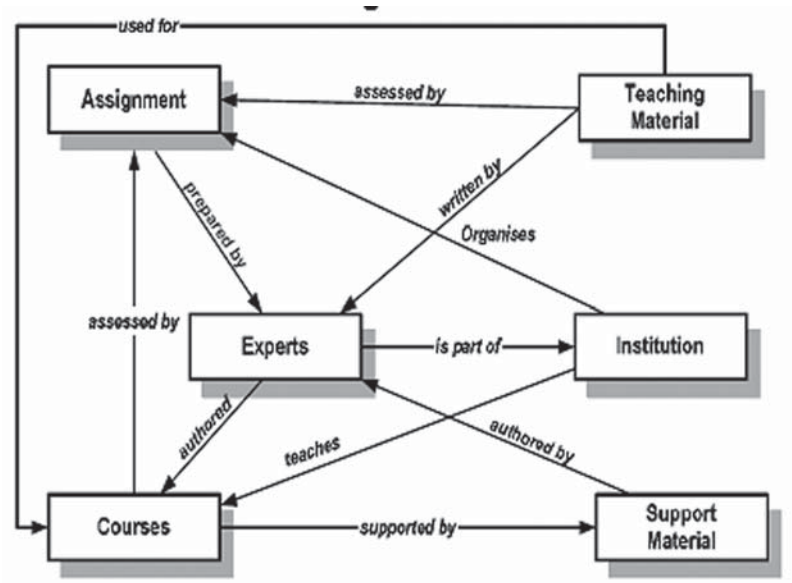


Figure 14. E-learning Ontology Design Schema

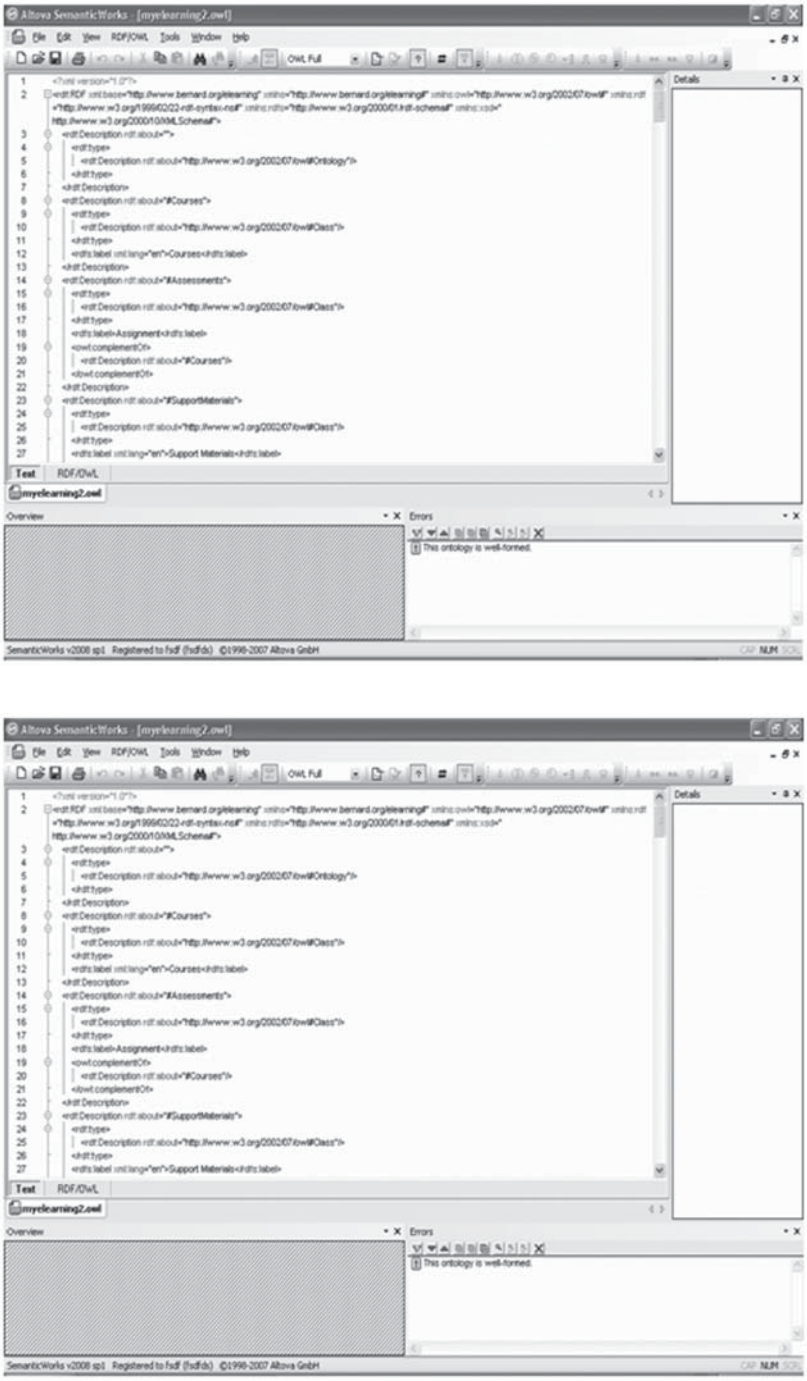


Figure 15. Ontology Based on Metadata RDF format

4.2. Utilizing Altova Semantic Work Tool

To design the ontology, researchers use the Altova Semantic Work Tool, which provides ontology design using visual presentations. With this tool, researchers can customize RDF, RDFS, and OWL as well as the syntaxes, which are related to the semantic.

As an example of ontology for the Courses and Experts categories, researchers present the design as shown in Figure 16.

The RDF representations for ontology in the Courses and Experts domains are as follows (Figure 17).

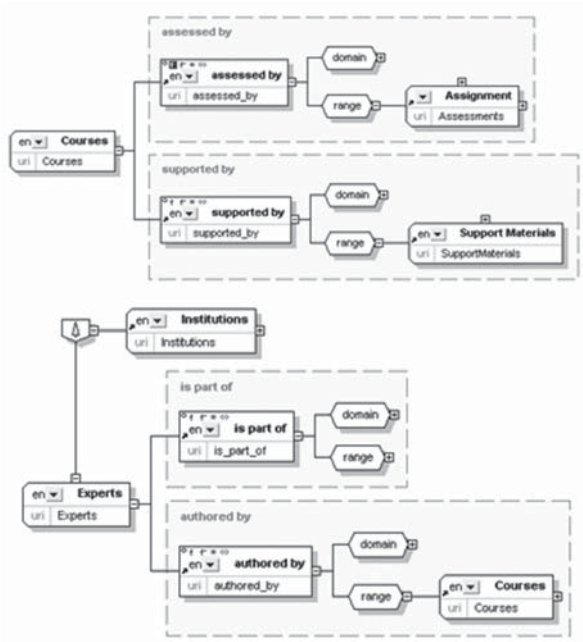


Figure 16. Ontology Diagram for Courses and Experts Domains

```
<rdf:Description rdf:about="#Courses">
<rdf:type>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#Class"/>
</rdf:type>
<rdfs:label xml:lang="en">Courses</rdfs:label>
</rdf:Description>
<rdf:Description rdf:about="#assessed_by">
<rdf:type>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#ObjectProperty"/>
</rdf:type>
<rdfs:label xml:lang="en">assessed by</rdfs:label>
<rdf:type>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#FunctionalProperty"/>
</rdf:type>
<rdfs:domain>
<rdf:Description rdf:about="#Courses"/>
</rdfs:domain>
<rdfs:range>
<rdf:Description rdf:about="#Assessments"/>
</rdfs:range>
</rdf:Description>
<rdf:Description rdf:about="#supported_by">
<rdf:type>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#ObjectProperty"/>
</rdf:type>
<rdfs:label xml:lang="en">supported by</rdfs:label>
<rdfs:domain>
<rdf:Description rdf:about="#Courses"/>
</rdfs:domain>
<rdfs:range>
<rdf:Description rdf:about="#SupportMaterials"/>
</rdfs:range>
</rdf:Description>
```

Figure 17. RDF Schema for Ontology on Courses and Experts Domains

As shown in Figure 17 and Figure 18, the Courses domain possesses correlations in the form of “assessed_by” property with the Assessment domain, and “support_by” property with the Support Materials domain.

4.3. Ontology Test using pOWL

The compatibility of the ontology results can be tested using pOWL. pOWL, which is a web-based application for collaborative web semantic development. pOWL possesses the SQL query capability based on API to handle the RDF, RDFS, and OWL layers.

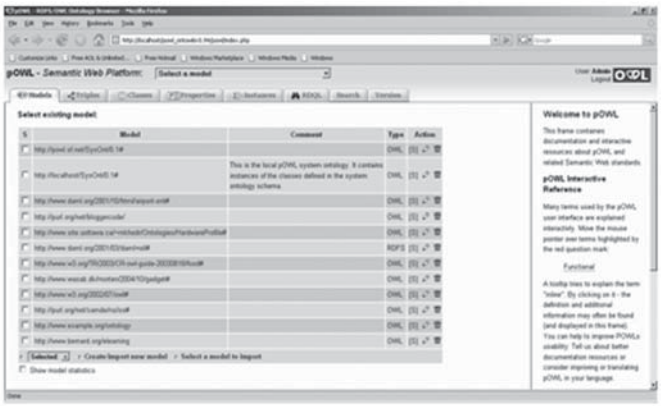


Figure 18. Initial View of pOWL

The following Figure 19 shows the results from Class, Properties, and Instance from the ontology designed.

4.4. Ontology-based E-learning System Design

The researchers developed the e-learning system based on object-oriented programming using the LAMP technology and Prado framework. The Class diagram for the system is as show in figure 20.

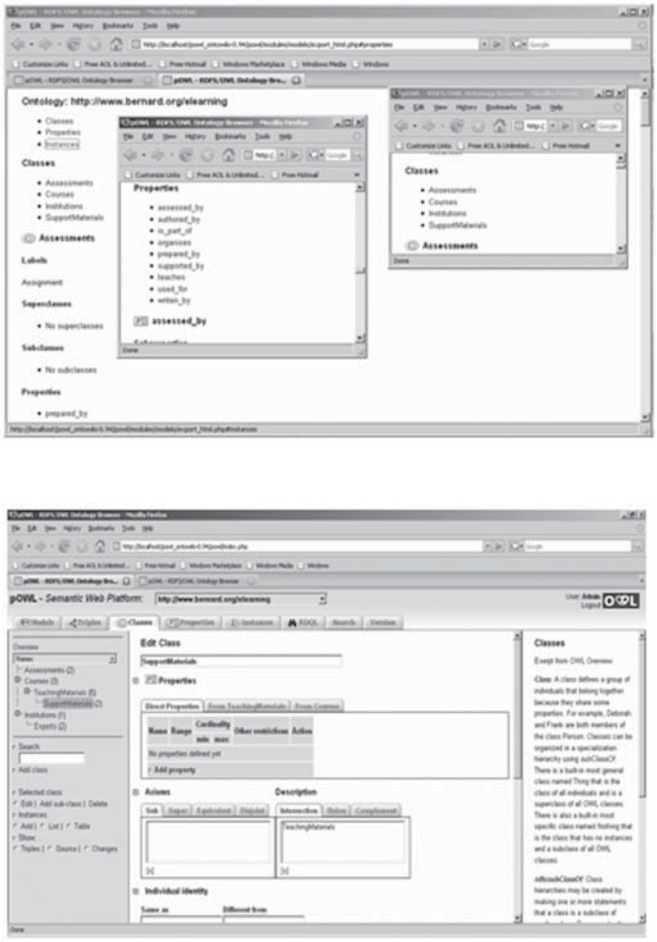


Figure 19. Class, Properties, and Instance Views

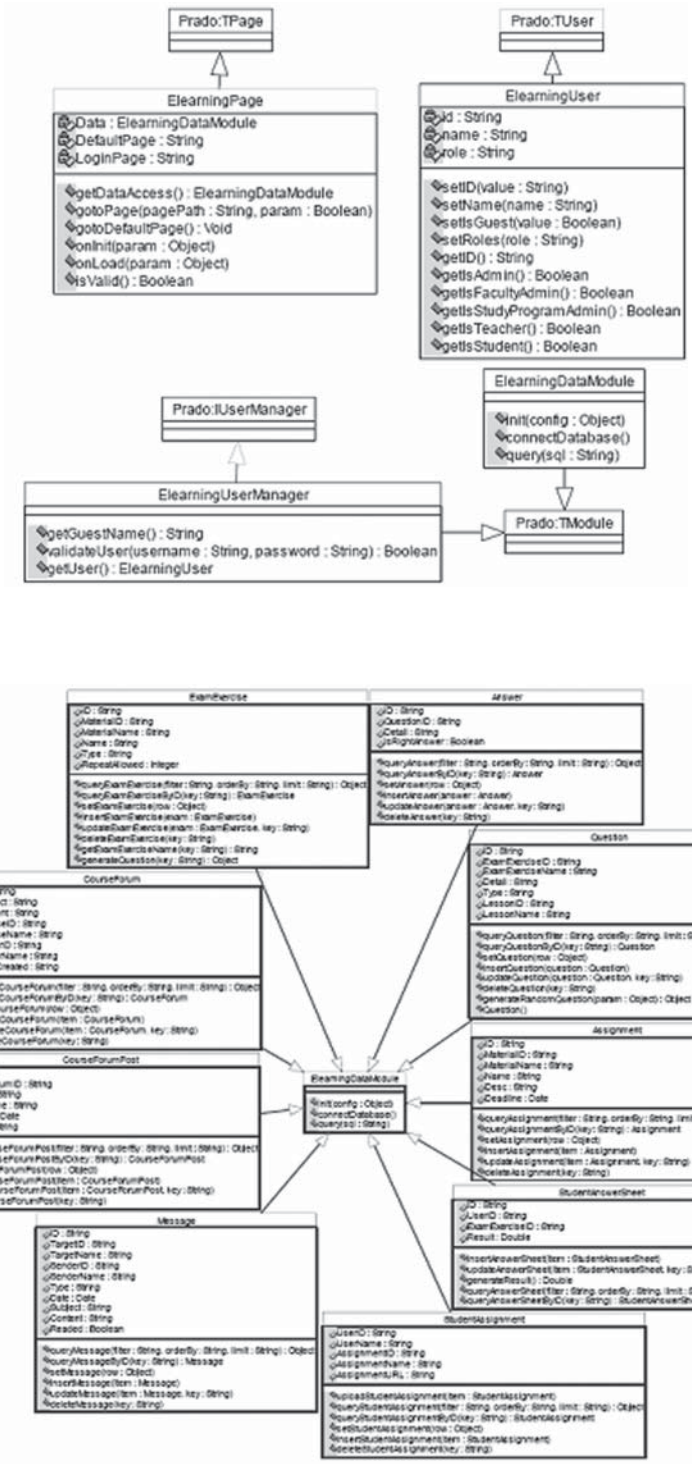


Figure 20. Class Diagram on the E-learning System

E-LearningPage class is a derivation from the TPage class. The E-LearningPage class provides method that is related to the web pages such as page movement, page initialization, and view page content. The following is the description of methods available in the E-LearningPage class: TUser class. E-LearningUser class is a derivation from TUser class. The E-LearningUser class fulfills the needs for user login information. E-LearningDataModule class is a derivation from TModule class. The E-LearningDataModule class fulfills the needs for connection to the database.

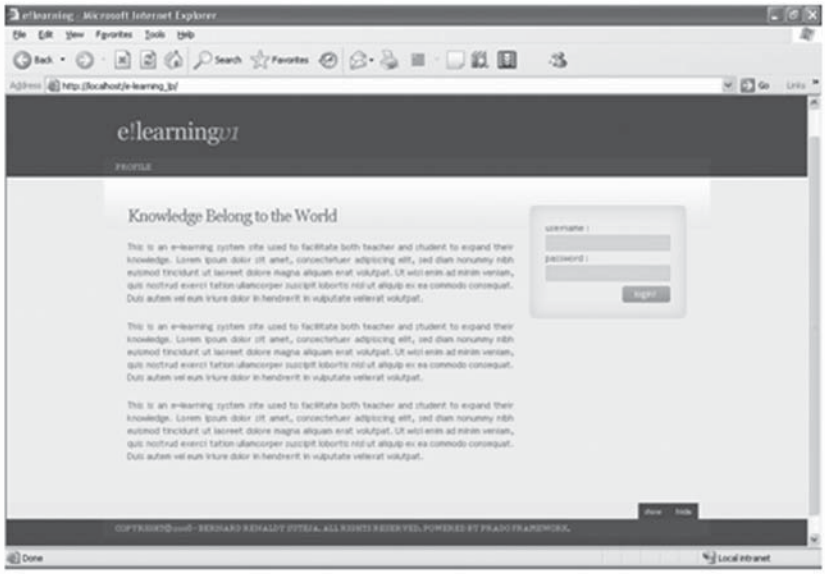


Figure 21. Initial View of the System

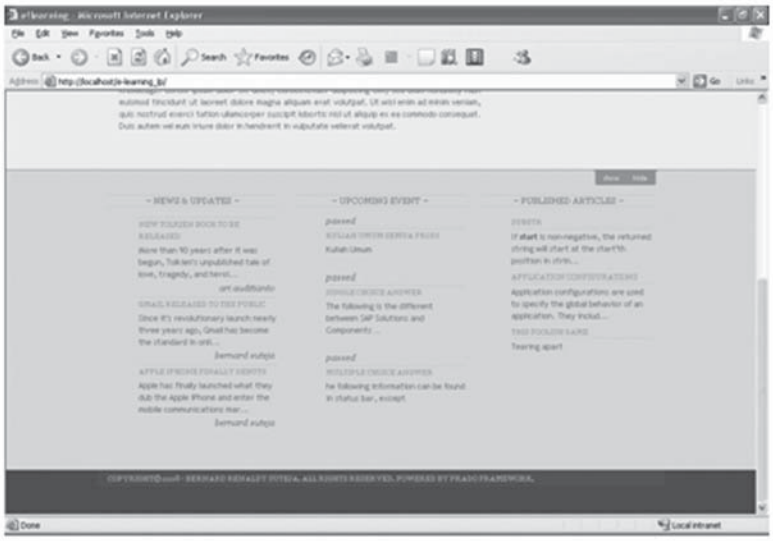


Figure 22. News, Events, and Articles View

5. System Implementation

In the initial part of the system utilization is the user authentication. Each registered account will possess different access levels and different ontology creation from the knowledge formed in each user's learning level.

The initial view provides the latest news, events, and articles as provided by the system administrator.

The users who login to the system will find a systematic pull down menu on the top of the screen. The menus shown will depend on the users' access level. The initial profile setup will become the benchmark to analyze the users' capability and adaptation.

5.1. Practice and Exams Management

The following is the user interface implementation to manage the practice and exams problems. The test problems, using the ontology agent, can be tailored to the users' capability and adaptation.

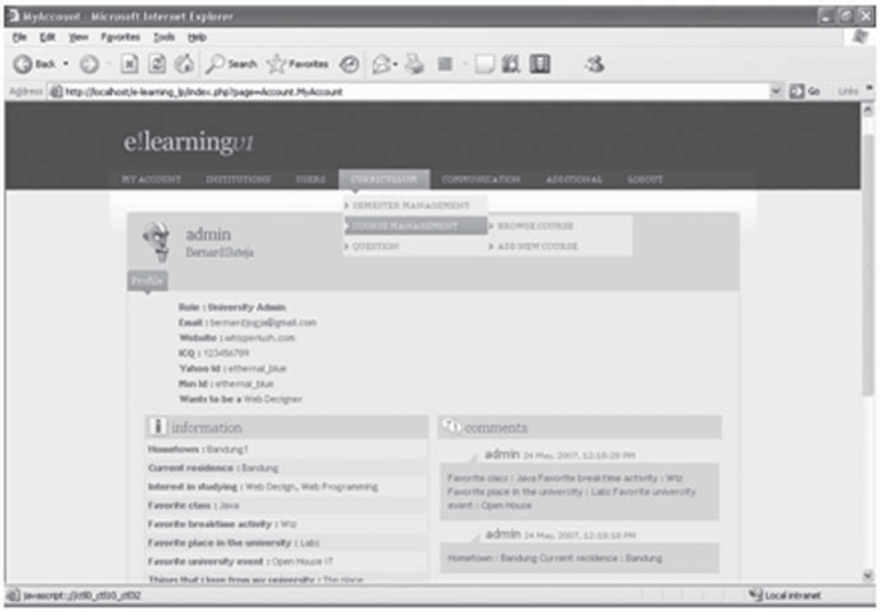


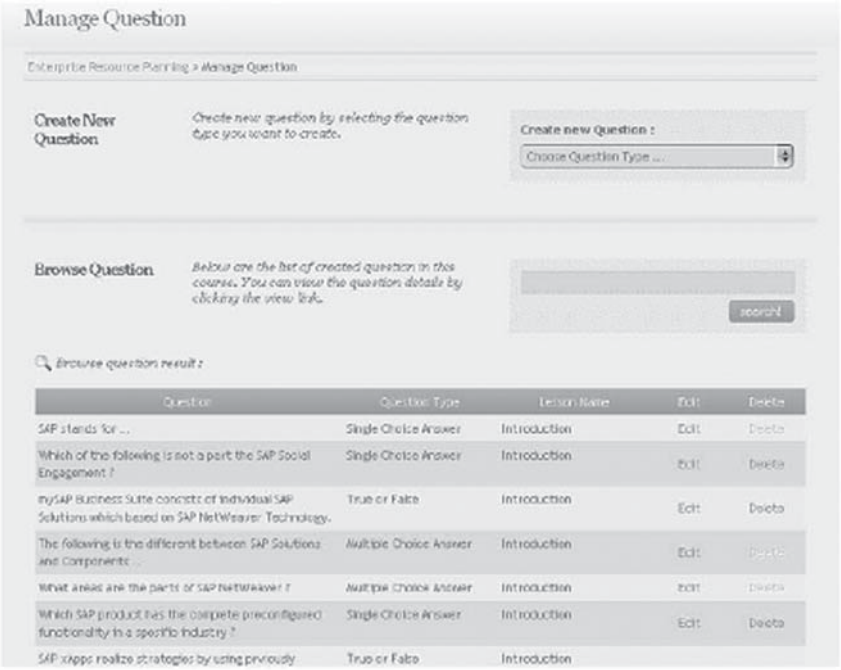
Figure 23. User Profile View

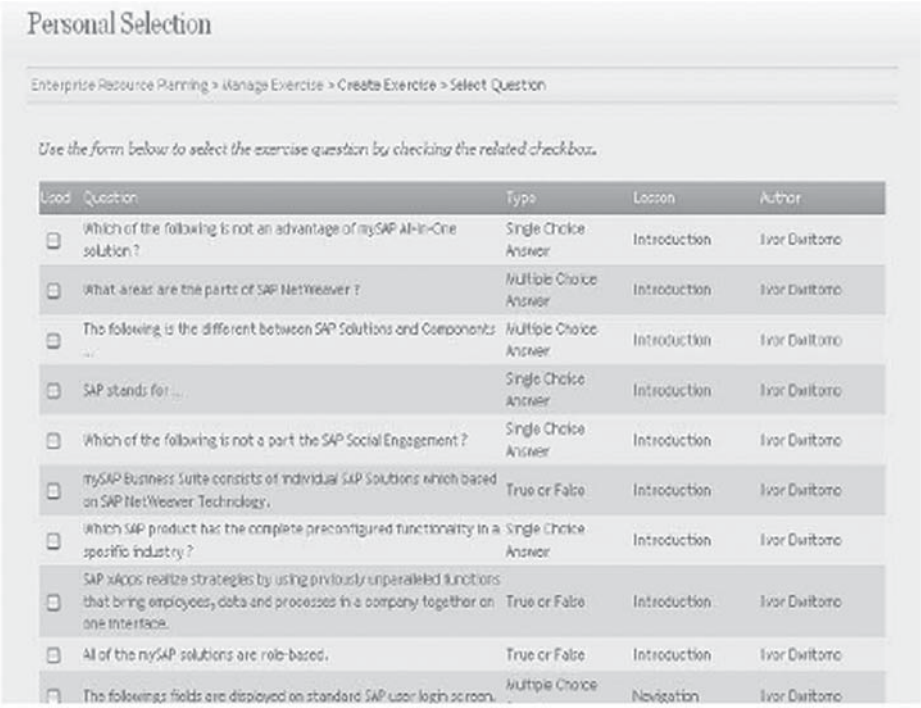
5.2. Assignment Management

The following assignment management uses the ontology agent to analyze the repository knowledge formed and tailor the assignment to the users' level learning level, based on the users' capability and adaptation. The assignments given will appear along with the Web 2.0 knowledge resources such as Wikis, Flickr, etc.

6. Conclusion and Further Work

The researchers designed the e-learning prototype using the ontology in education, specifically for teaching and learning. The following statements conclude the benefits of ontology utilization to develop an e-learning system:





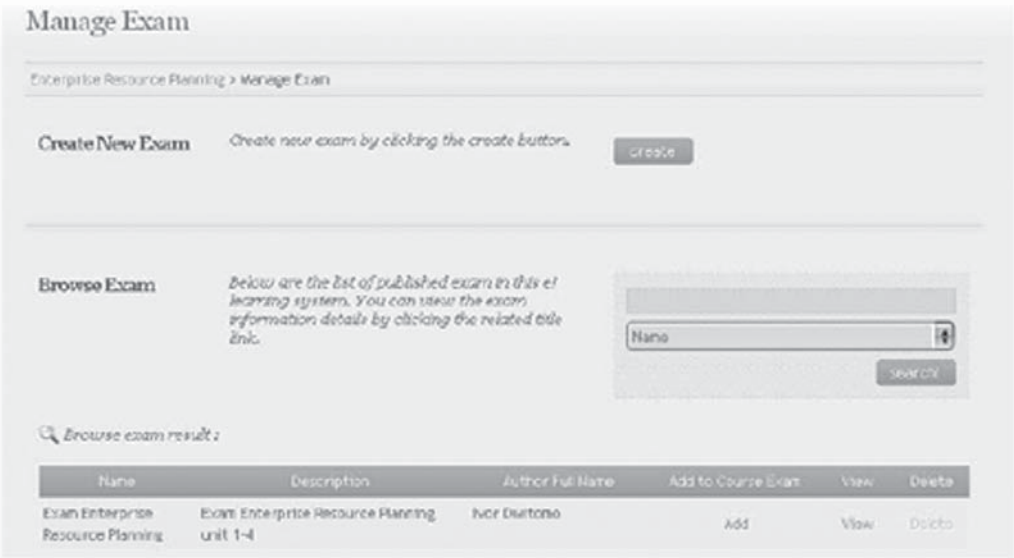


Figure 24. Manage Exams View

- Improves learning quality
- Provides directions for instructors and students to obtain more relevant information
- Provides effective level on the information retrieval
- Creates agent which handle the ontology-based knowledge repository
- Provides ease of access to the right information
- Optimize teaching and/or learning for the users

The ontology design in this research can establish a better-organized e-learning system in term of the content utilization. In the future, there should be an expansion and development for additional ontology domains to improve the integrity within the e-learning system itself and in relations with other e-learning systems.

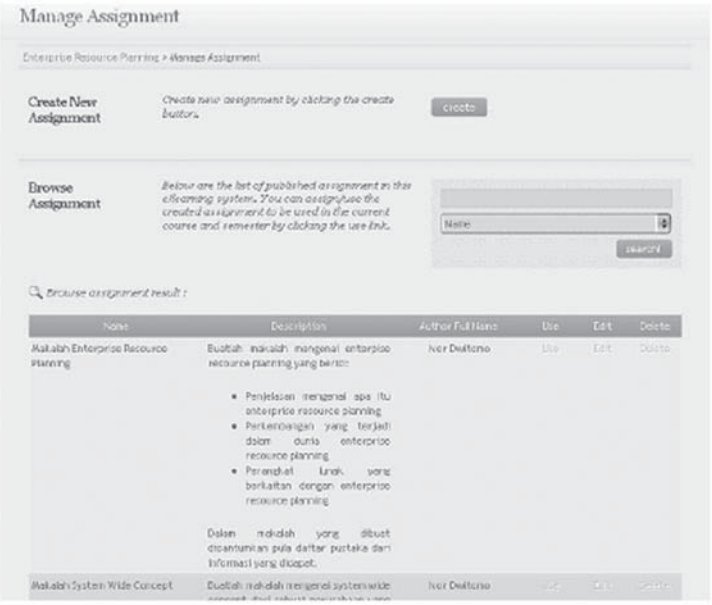


Figure 25. Assignment Management

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