Journal of Communications Technology, Electronics and Computer Science, Issue 2, 2015
ISSN 2457-905X

Application of Ontology from Course and Forum Discussion Learning Content

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***Abstract* - The capability of an ontology application to add meaning to information, indexed in such a way that it can be reused, searched, processed and shared has been extensively explored and recognized in e-learning education. As such, it is the interest of this paper to apply the use of ontology from course module and forum discussion learning content in e-learning setting. This study designs an ontology with Simple Knowledge Organization Systems (SKOS) specification in order to structure the learning content with concepts and relationships approach that is able to highlight what is important and needs to be learned from the course taught. Furthermore, a semantic forum system is proposed from the ontology designed as a mechanism to represent the indexed learning content for learner to easily access, search and navigate the relevant knowledge of interest.**

Keywords - e-learning; ontology; SKOS; forum discussion; course module; semantic forum

I. INTRODUCTION

Many have suggested e-learning education to focus on continuous exploration and development of new learning technologies to further facilitate and improve learning effectiveness [1, 2]. Despite various web based learning content that is managed through the use of learning management system, the main learning content used to achieve a desirable learning outcome still highly depend from course module or textbook and forum discussion. A course module refers to a unit of teaching or an academic course taught in a semester or one academic term. It contains well-organized structured content presented in a hierarchical structure with chapters, sections and subsections on the course of concern. Meanwhile, forum discussion is a communication platform that provides opportunities for reflective learning, sharing opinions, problem solving, articulation and collaboration among peers and tutors. This platform is capable to build very large archives of question-answer content across courses and semesters over the time.

Therefore, mining and reusing such content is highly desirable and valuable to enhance learning from the course taught. Although many researchers claim the importance of reusing such content, few have taken efforts to compile, organize and represent this content. This is because mainly forum discussion is not formally organized and scattered throughout huge textual resources. Furthermore, classifying, extracting, accessing and reusing relevant knowledge of, interest from such a pool of "unstructured" question-answer content is challenging tasks, so do effort to integrate this content with course module. What is required is a method of responding more rapidly to the needs and inquiries, reduce rework and just in time to help learners to learn [3].

Therefore, this study aims to apply the use of ontology from course module and forum discussion learning content. Ontology is used to formally represent the knowledge structure of learning materials [4] and able to describe an area of knowledge by defining the common concepts of that domain with concepts properties and relationships [5]. Ontology driven implementation has already been recognized and used in e-learning education [6-9] with different purposes ranging from the definition of a domain-specific terminology to the use of conceptual models and inference in the generation and composition of learning content and systems.

II. APPLICATION OF ONTOLOGY

The term ontology is borrowed from the field of philosophy that is concerned with the study of being or existence. The term has emerged in the field of computer and information science, denoting the meaning of ontology as an artefact that is designed to model any domain knowledge of interest. The most widely cited definition of ontology in the computer field is from Gruber [10] which defines it as an ''explicit specification of a conceptualization'. In other word, it means that the ontology is able to explicitly define (specifies) concepts and relationships that are relevant for modelling domain of interest. The specification can takes in the form of classes, relations, constraints and rules to provide more meanings of vocabulary use.

In order to describe the importance of ontology in structuring the knowledge of interest, Fig. 1 shows the level of semantics, where the ontology represents the highest semantic richness or strong semantics of all knowledge organization systems. Meanwhile, Fig. 2 illustrates on how ontology can provide a means in adding semantics to web resources [11]. On the left side of Fig. 2, a diagram representation of the normal web is given. Resources are linked together forming the web. There is no distinction between resources or the links that connect resources. To give meaning to resources and links, ontology is used aided with semantic web technologies standard and languages. The rules and descriptive information made available by these languages allow the type of resources on the web and the relationships between resources to be characterized individually and precisely, as illustrated on the right side of the Fig. 2. Fensel [12] additionally states ontology bring the web to its full potential by uniting two important aspects which are to describe real-world semantics and to allow machines to process these translated formal semantics for information.

This study reuses learning content from System Analysis and Design (SAD) course module and forum discussions. The SAD course is chosen because it is a core subject in a mature computing discipline and it is offers for every semester to the learners. The ontology is designed based on ontology engineering method developed by Uschold and Gruninger [13] that involves 1) identification of the key concepts and relationships in the domain of interest, 2) production of precise unambiguous text definitions for these concepts and relationships, 3) identification of terms to refer to such concepts and relationships, and finally, reaching agreement on all of these.

In order to offer semantic richness from the ontology designed, the reuse of specification from existing knowledge organization standard is a priority. Thus, this study extends Simple Knowledge Organization Systems (SKOS) ontology developed by the World Wide Web Consortium (W3C) community as a standard to classify and index the learning content. SKOS is a common ontology model for sharing and linking knowledge organization systems such as thesauri, taxonomies, classification schemes, structured controlled vocabulary and subject heading systems via the Web [14]. Thus, the SKOS specification for the ontology designed is presented in Table I.

The process to capture the learning content into ontology began with a structuring the SAD course into concepts and its relationship according to SKOS specification. Concept is defined as key terms or keywords discussed in the course module. Fig. 3 indicates an example of identified concepts and types of relationships used in this study. Organization of concepts according to appropriate relationship types able to help learners to see the structure, understand what is important and what should be learned of such concept. The use of concepts and its relationships is similar to a dictionary or glossary, but with richer structure, relationships and axioms that describe the domain knowledge more precisely [15].

The TopBraid Composer software as an ontology authoring tool, illustrated in Fig. 4 was used to encode the course knowledge in Web Ontology Language (OWL). OWL is a language developed by W3C for defining classes and properties. OWL can be used to explicitly represent the meanings of concepts in vocabularies and the relationships between those concepts. OWL represents those concepts in the form of triples representation (*subject, property, object*) as illustrated in Fig. 5.

III. Semantic Forum System

The application of ontology in structuring the content from course module and forum discussion was carried out by knowledge engineer or developer. This task requires the developer to have an appropriate ontology engineering method, languages and authoring tool background. Therefore, this study proposes a semantic forum system as a front end mechanism to represent the ontology designed into semantic knowledge representation for learner to easily access, search and navigate the relevant knowledge of interest. The system introduces a new way of storing, organizing, searching and exchange relevant concepts and discussions that able to facilitate the course to be reused, evolved and resolved learning difficulties. Thus, this section briefly discusses the system's facilities and its usage.

Fig. 6 illustrates an interface that provides concept information details. The information includes: *concept relationships* section which can be narrower, broader or related concepts; *notes* section that provides notes taken from course module by such concept; *other* section: list of synonyms or alternative words in English or Malay language to be represented and link to Wikipedia or other sources that is relevant by such concept; and *related question* section that provides relevant questions and answers reused from several semesters of forum discussion collection. These details allow the course content to evolve for further discussion, understanding and revision for current and future members of the learning community.

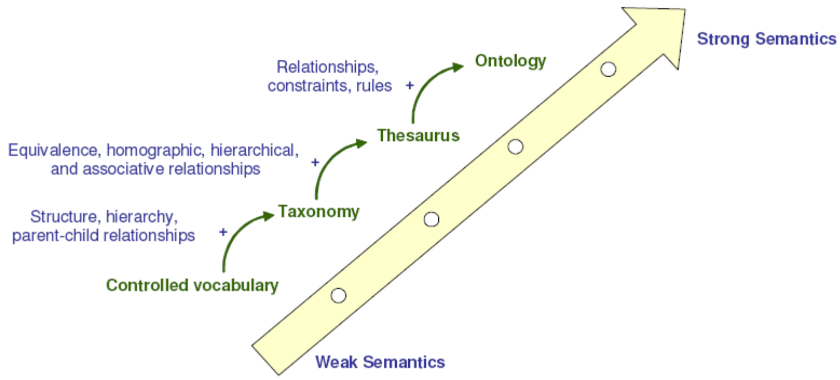

Fig. 1. Level of semantics for ontology

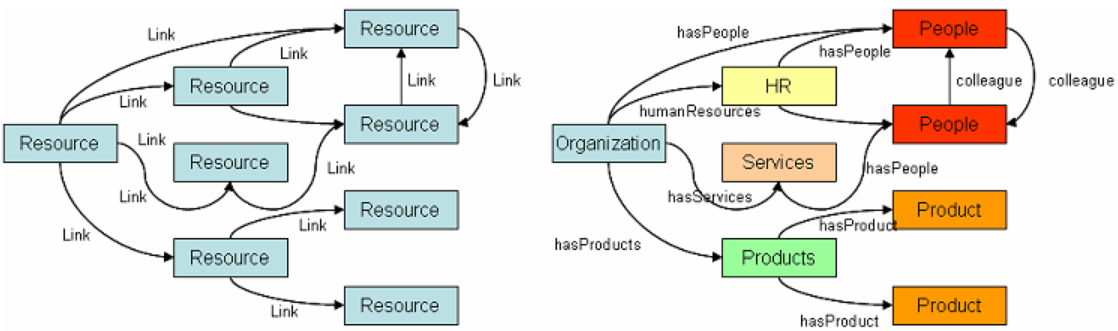

Fig. 2. Evolution of the web

TABLE I. SKOS specification

Term	**Definition**
skos:Concept	An abstract idea or notion; a unit of thought.
skos:ConceptScheme	A set of concepts, optionally including statements regarding semantic relationships between those concepts.
skos:hasTopConcept	A top level concept in the concept scheme.
Semantic relationships properties	
skos:broader	Relates a concept to another concept that is more general in meaning.
skos:narrower	Relates a concept to another concept that is more specific in meaning.
skos:related	Relates a concept to another concept with which there is an associative semantic relationship.
Documentation properties	
skos:prefLabel	The preferred lexical label for a resource, English language
skos:altLabel	An alternative lexical label for a resource, Malay language
skos:note	A general note for any purpose
skos:links	A general link for any purpose

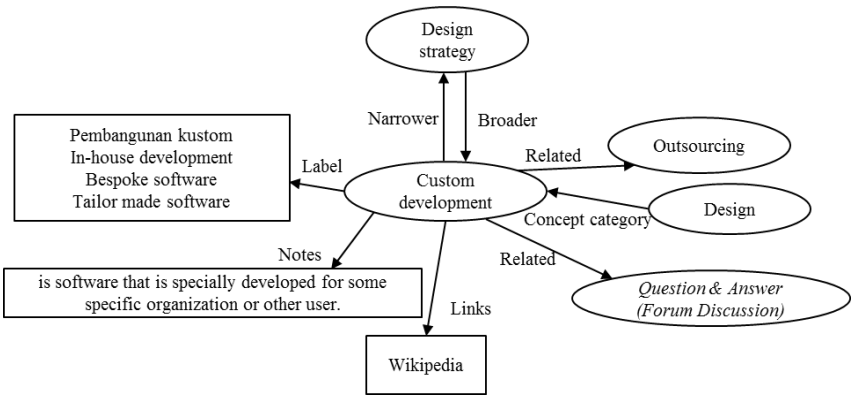

Fig. 3. Example of concepts and its relationships

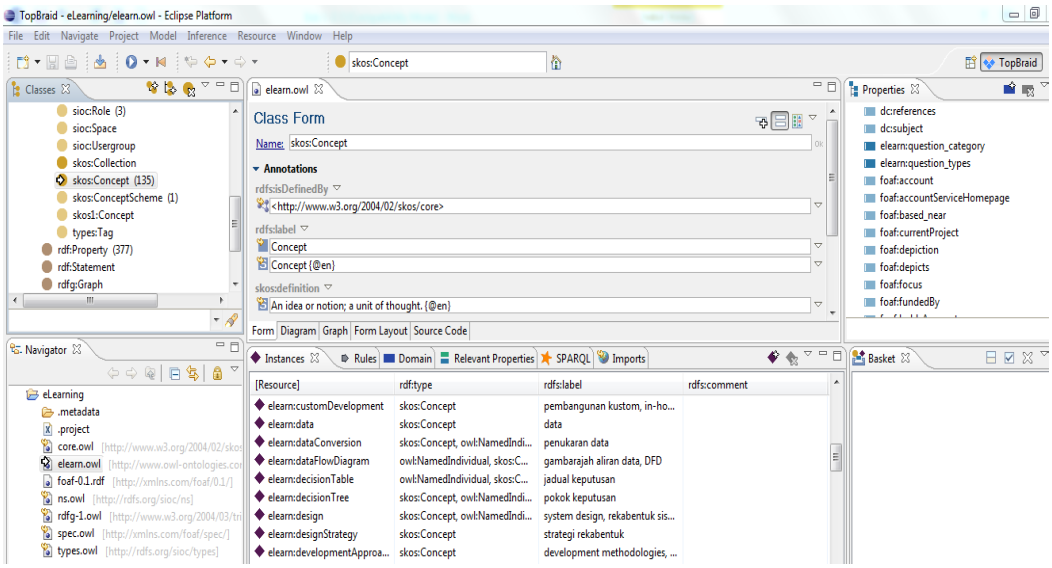

Fig. 4. Ontology authoring tool

Subj	Prop	Obj
Uv::http://purl.org/dc/elements/1.1/description:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#AnnotationProperty:
Uv::http://purl.org/dc/elements/1.1/title:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#AnnotationProperty:
Uv::http://purl.org/dc/elements/1.1/date:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#AnnotationProperty:
Uv::http://www.w3.org/2000/01/rdf-schema...	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#Class:
Uv::http://xmlns.com/foaf/0.1/LabelProperty:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2000/01/rdf-schema#Class:
Uv::http://xmlns.com/foaf/0.1/LabelProperty:	Uv::http://www.w3.org/2003/06/sw-vocab-status/ns#t...	Lv:0::unstable:
Uv::http://xmlns.com/foaf/0.1/LabelProperty:	Uv::http://www.w3.org/2000/01/rdf-schema#label:	Lv:0::Label Property:
Uv::http://xmlns.com/foaf/0.1/LabelProperty:	Uv::http://www.w3.org/2000/01/rdf-schema#comment:	Lv:0::A foaf:LabelProperty is any RDF property with texual ...
Uv::http://xmlns.com/foaf/0.1/LabelProperty:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#Class:
Uv::http://xmlns.com/foaf/0.1/LabelProperty:	Uv::http://www.w3.org/2000/01/rdf-schema#isDefinedBy:	Uv::http://xmlns.com/foaf/0.1/:
Uv::http://xmlns.com/foaf/0.1/Person:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2000/01/rdf-schema#Class:
Uv::http://xmlns.com/foaf/0.1/Person:	Uv::http://www.w3.org/2000/01/rdf-schema#label:	Lv:0::Person:
Uv::http://xmlns.com/foaf/0.1/Person:	Uv::http://www.w3.org/2000/01/rdf-schema#comment:	Lv:0::A person.:
Uv::http://xmlns.com/foaf/0.1/Person:	Uv::http://www.w3.org/2003/06/sw-vocab-status/ns#t...	Lv:0::stable:
Uv::http://xmlns.com/foaf/0.1/Person:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#Class:
Uv::http://xmlns.com/foaf/0.1/Agent:	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#Class:
Uv::http://xmlns.com/foaf/0.1/Person:	Uv::http://www.w3.org/2000/01/rdf-schema#subClassOf:	Uv::http://xmlns.com/foaf/0.1/Agent:
Uv::http://www.w3.org/2000/10/swap/pim/c...	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#Class:
Uv::http://www.w3.org/2000/10/swap/pim/c...	Uv::http://www.w3.org/2000/01/rdf-schema#label:	Lv:0::Person:
Uv::http://xmlns.com/foaf/0.1/Person:	Uv::http://www.w3.org/2000/01/rdf-schema#subClassOf:	Uv::http://www.w3.org/2000/10/swap/pim/contact#Person:
Uv::http://www.w3.org/2003/01/geo/wgs84 ...	Uv::http://www.w3.org/1999/02/22-rdf-syntax-ns#type:	Uv::http://www.w3.org/2002/07/owl#Class:

Fig. 5. Concepts in triples representation

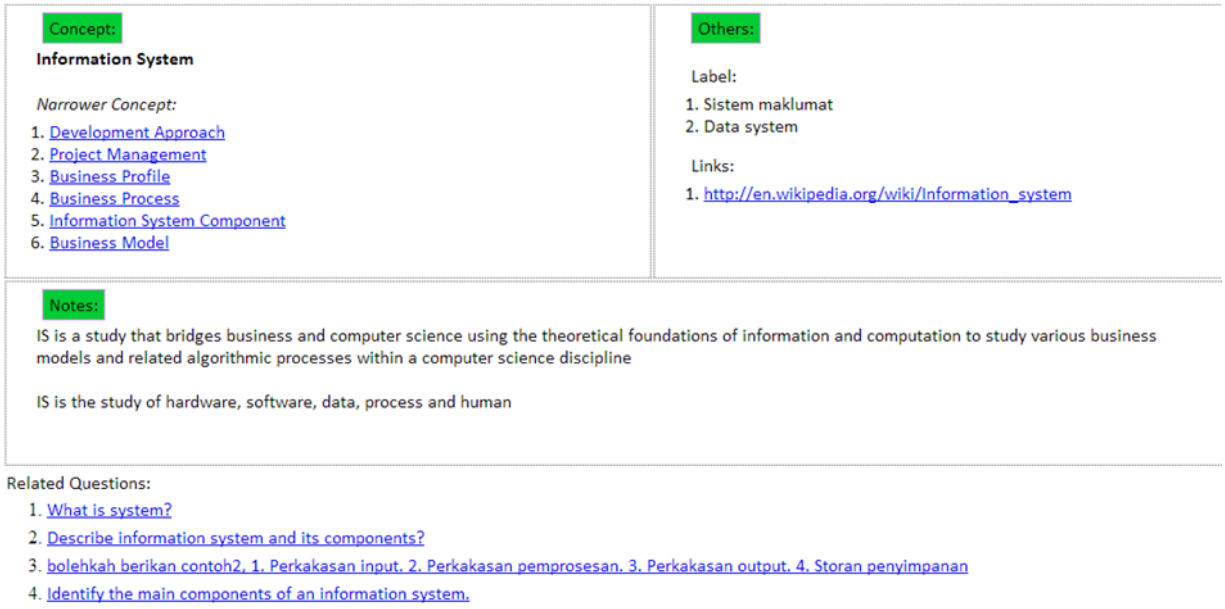

Fig. 6. Example of concept detail interface

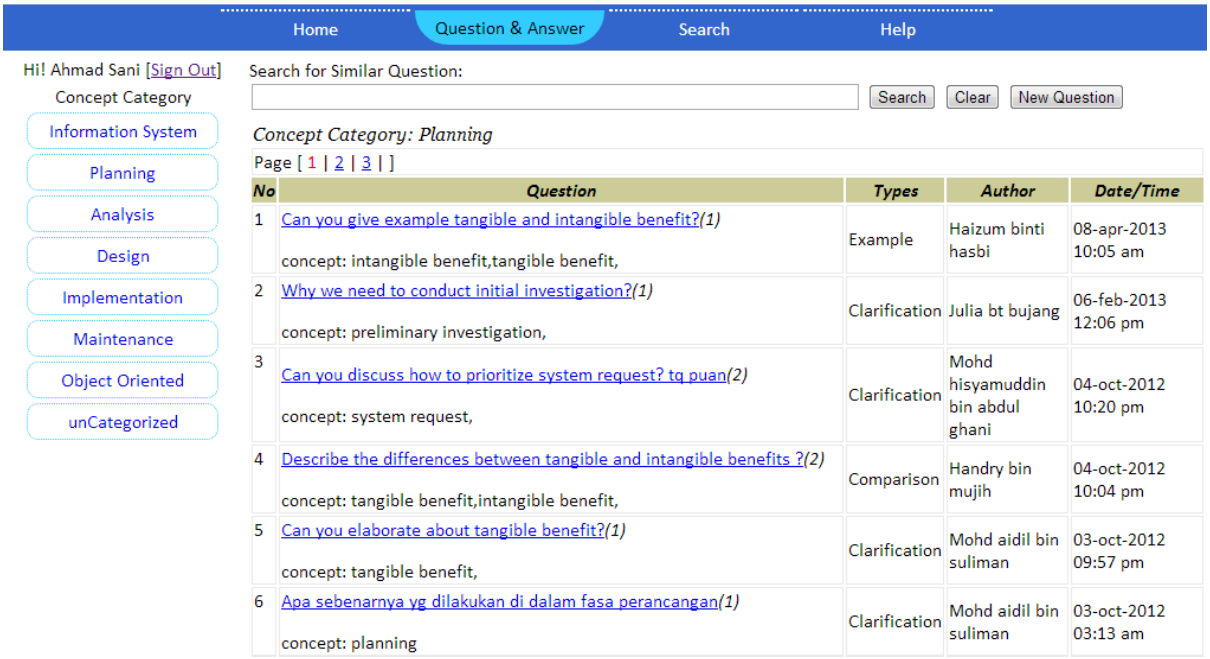

Fig. 7. Example list of discussion questions interface

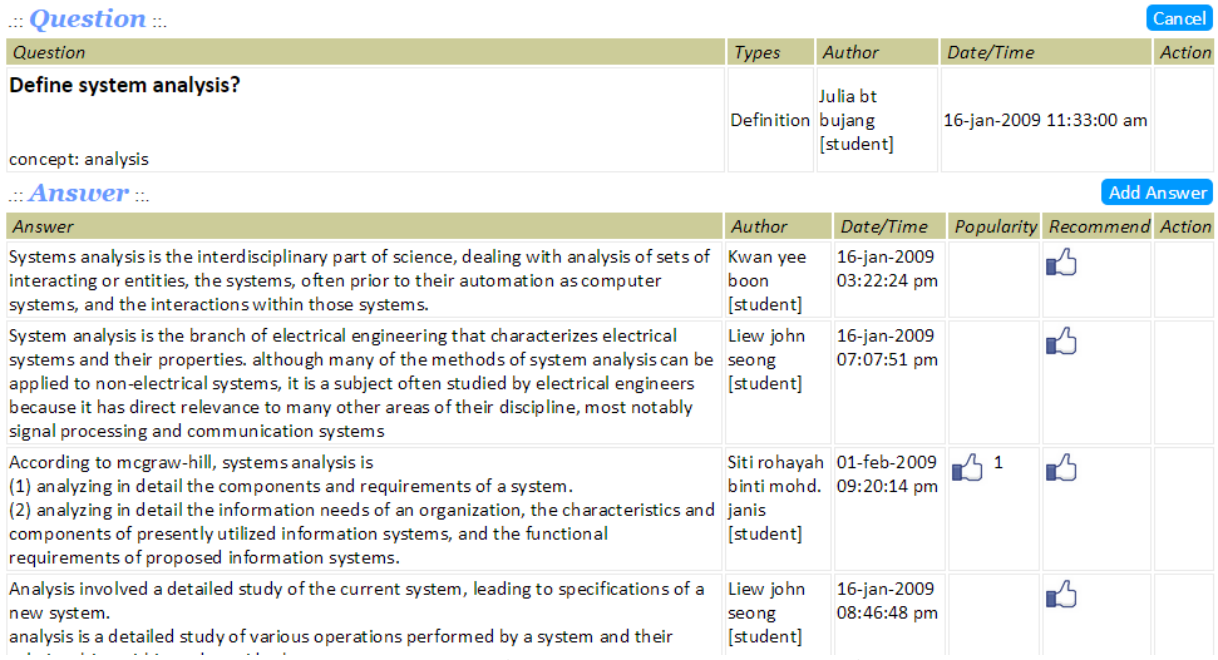

Fig. 8. Example of question and answer discussion interface

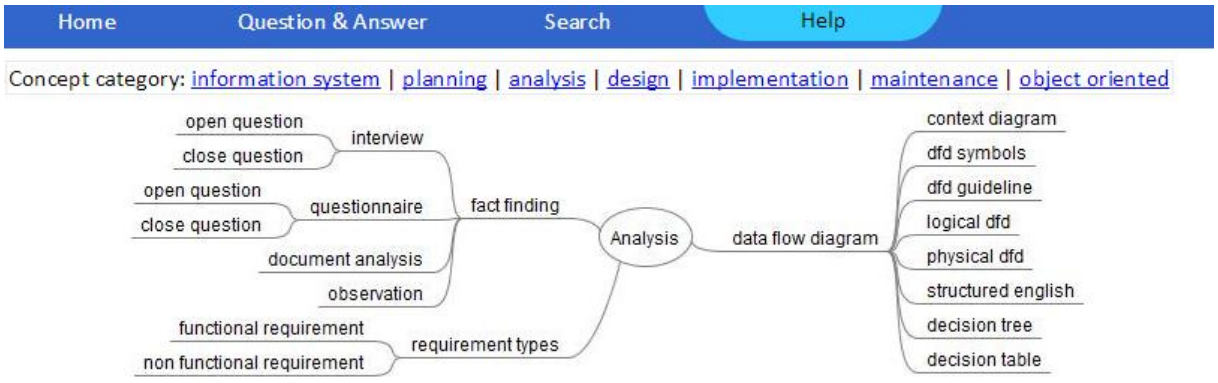

Fig. 9. Example of concept map interface

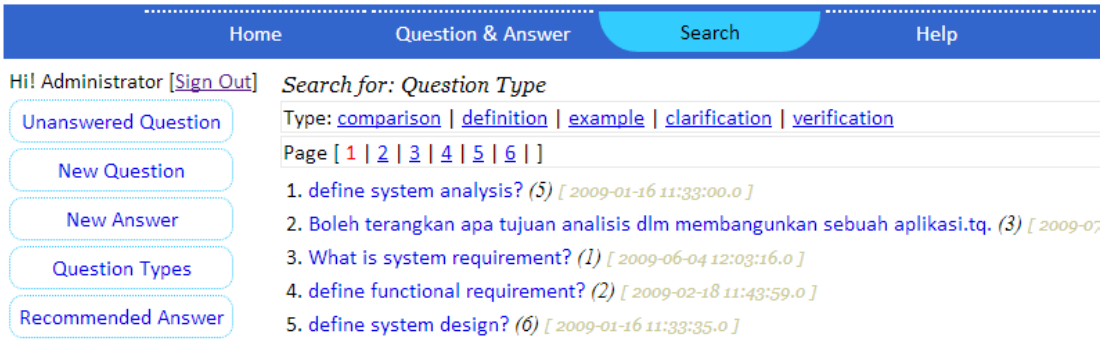

Fig 10. Example of question type search interface

Fig. 7 illustrates a list of discussion questions organized under certain concept category. This concept category functions to represent the delivery sequence of the knowledge structure in the SAD course. Learner able to navigate from one question to another with additional information provided in the interface such as to which concept(s) the question belongs to, types, author, date and time the question posted. Upon selection from any of the questions listed, several answers for such question are displayed as illustrated in Fig. 8. In this interface learner has an option to add a new answer for further choices of the answer or option to recommend whichever answer that best reflect their understanding. Meanwhile, Fig. 9 illustrates the concepts and relationships between the concepts using a concept map diagram. This initiative contributes to reflect the essential aspects or the big picture of the course taught, namely what is important and needs to be learned. The system also offers several types of searching facilities, such as searching for concepts, similar questions, unanswered questions, new questions, new answers, question types and recommended answers. Fig. 10 illustrates a search driven by question type classification, namely comparison, definition, example, clarification and verification. On the left side of the interface, the learner does have the option to choose several other types of searching facilities provided in the system.

IV. Conclusion

Having a meaningful, relevant, rich and just in time learning content is critical to accommodate desirable learning outcome. So do exploration and development of ontology that is able to manage and reuse the existing learning content which is significant to enrich further learning and revision to fulfil learning needs. This study aims to use ontology application from course module and forum discussion learning content. This application is important to add meaning to the learning content, indexed in such a way that it can be reused, searched, processed and shared in a new way of knowledge representation. However, to make it accessible for the ontology designed, a semantic forum system is proposed bringing the learning experience to the next level. The system is designed with concepts and relationships that provide a tool to highlight the essential aspect of the course of what is important and need to be learned. This study provides insights on new learning technology driven by ontology application used to further strengthen e-learning system to address learning needs and outcome. Future research efforts for continuous learning enhancement are to deliver the system in a way that can match the preferred learning style by varying the sequentialization of content elements or in a way that matches diverse teaching strategies such as game base learning, simulation, role playing and case study.

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