CREATING ONTOLOGY BASED CONCEPT MAPS WHICH CAN BE QUERIED IN COMPUTER ENVIROMENT

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Abstract: Nowadays, Semantic web and ontology applications which came with it, are commonly used in social media, entertainment and shopping sites. But usage of semantic web in education field is limited. Semantic web applications are useful developing tools and E-Learning objects can be used for creation and editing. It is important that Individuals on the internet arrange educational techniques based on their interests and needs (Stutt & Motta 2004). Thus, it is envisaged that, semantic web applications will have large contribution conception when moving to individualized education in future education. The aim of this study is to create concept maps for educators, which is one of the significant learning techniques and widely applied in the teaching process, by using ontologies. In accordance to this aim, an ontology based system made with "Protégé 4.3" developing tool based on RDF(Resource Description Framework) language and can be queried in E-Learning environment by using ontology query language SPARQL (SPARQL Protocol and RDF Query Language). Moreover, the developed system is able to present concepts visually to educators, which could not be done by concept maps generated with classic methods and ensured to access textual information. Therefore, students are able to perform better relations between former and recently learned concepts and achieve constructive learning easier. In future studies, ontology based concept maps which is only used as learning material in education phases, are expected to be used more effectively also in planning, learning and evaluation stages.

Key Words: Semantic, Ontologies, Concept Maps, Constructive Learning, SPARQL

Introduction

As it will be made many definitions of Education, today's most commonly used definition is the behavior of individual, is the process of deliberately bring about the desired change in the direction of their lives through. All developed countries have education systems that hosted within their own social values to transfer their cultural heritage to the next generation. In recent years, these systems need to be constantly renewed with the rapid developments occurring in the field of science and technology. The ultimate aim of governments in education systems is to ensure the training of qualified individuals which produce knowledge, questioning, critical thinking, criticizing and judgment maker which can be used for purposes of science and technology (Gültepe, 2014, p.24).The most critical point in the system for training established teaching is how to plan and implementation of education. Academic work in the field of education is focused in direction of "the development of effective educational system" (Ergin, 1991, p.371). Coming from the past to present, there are many methods and techniques of teaching-learning strategies. Strategies, methods and variations in techniques makes learning more effective and easier. Therefore, teaching and learning strategies, significantly affects student achievement (Tekışık, 2002, p.1).

In this study, the creation of computer-aided concept maps was achieved using ontologies. In the second part of this study, the development of concept maps which is an effective educational method and importance of it has been emphasized in terms of education. Ontologies are defined which determine how to read and interpret well-defined web data using machines. Similarities and superior sides of concept maps with ontologies according to each other are discussed. Also definition of SPARQL (SPARQL Protocol and RDF Query Language) ontology query language has been discussed. In the third part of this study, with examples it has been described that of how to create an ontology using protégé editor. It has been discussed how to transfer the created ontology to web environment and how to query these concept maps which are created with support of ontology using SAPRQL. In the fourth part of the study, it mentioned results and future works planned to be done in the future.

Meaningful Learning and Concept Maps

One of the widely used strategies of Teaching-learning is David Ausubel's (1963) verbal based teaching technique. Even though there are different methods to achieve meaningful learning the concept maps are one of the most effective learning methods (Kaptan, 1998, p.95). At first, Tony Buzan introduced concept maps to world with publishing books about it, at the same time it has become a technique which in future many people will adopt and

use (Adodo, 2013, p.163). Novak and Gowin in 1984, show that using concept maps is a creative method when clarifying student's concepts in a particular domain and the relationship between these concepts. Justifying information requires a high level of learning. Concept maps makes learning discipline to scientists and individuals by simplifying the knowledge creation process. (Novak, 1993, p.167).

Concept maps can be considered as mechanisms which define concepts to be learned by students, and the relation to be made between these concepts and appeal to the visual senses for learning effectively. At the same time, it is indicated that using concept maps is an effective learning technique and the develop students' thinking, analyzing, problem solving and their creativity abilities (Novak & Gowin & Johansen, 1983 p.625). But despite of these benefits concept maps are not used efficiently as requested. This problem has two main reasons. First one is, having difficult and costly preparation and second one is limited reusability. In the latest researches, it has been envisaged that concept maps to be created using ontologies will solve these problems. The greatest feature of ontologies which are main structure of semantic web is reusability and created easily using editors. Thus it is expected to bring new perspective to concept maps. Ontologies makes creating concept maps for teachers easier (Chu, Lee & Tsai, 2011).

Semantic Web and Ontologies

Semantic web (Berners-Lee, 2001, p.34) is an internet plug-in that is mostly studied in the academic and industrial fields which goal is making language of data in the internet environment in a way that not only understandable by human languages, but also being understandable, interpretable and usable by machines, in this way machines can easily find information, which aims to share information and be able to combine them. The basic structure of the Semantic Web are ontologies. "Ontologies have key duty in technology by integrating interoperability and data, information and processes" (Grobelnik & Mladenic & Fortuna, 2009, p.59). Overall, Overall ontologies which is the most important component of semantic web based on RDF format. RDF is a data model to define data for semantic web. This model is based on objects in the web environment, the identification of resource properties and property values. RDF is made of RDF triples which are used to define and describe data. The objective of RDF triples is to store data as component forms. These triples are similar to the base sentence being used daily in dialogues, by having subject, predicate and the object. Subject shows data source, predicate shows properties of source and the relationship between subject and object.

When viewed this aspect, structure of ontologies which is conceptualized representation (Gruber, 1993) is similar to structure of concept maps which is a successful method of meaningful learning (Silva & Padilha et al. 2012, p.33). Concept maps and ontologies, while defining clearly classes and concepts and relationship between them, provide describe ability of the different concepts. Concept maps created using ontologies have differences with concept maps created using classic methods, because of including ability to define properties to classes, individuals and restrictions. (Hsieh & Lee & Chu, 2013, p.561). Concept maps created using ontologies in comparison to maps created using classic methods, has to offer more open and expressive form information (Graudina, Grunspenkis & Milasevica, 2012, p.29). Also, different from classic concept maps, ontology based maps shows more meaningful specifications by only using concepts and relation between concepts (Graudina & Grundspenkis, 2008, p.173).

Jena and Sparql

SPARQL is a query language used to query RDF data. SPARQL is used to make queries in different data resources. With having much similarity to SQL (Structured Query Language) language in terms of used words and structure, queries are written in triple store format.

Methods and Materials

Scope of the developed system is secondary school science and technology lesson. System is a web-based software, which can do semantic search and logical layoffs, because of being web-based anyone can use it independent of time and space. The base knowledge of the system in other words RDF triples is created using OWL language in Protégé 4.3 editor, developed by Stanford University. In the project, issues of primary school's science and technology lesson's concept's class features, limitations, qualifications and relations between these classes are designed using protégé. In the web-based application, developed RDF triples are queried using SPARQL ontology language and desired data depend on the user presented.

Ontology Development Process

Ontology development is an essential process that should be considered. The ontology development process should be made with specific methodology.t is the process that predicts which activity will take place. In this project, due to the ease of use and general acceptance by the investigators 101 methodology (Noy, N.F., McGuiness, D.L,

2001) is used. The basic steps of the methodology are as follows.

1. Determining the domain and scope of the ontology
2. Consider reusing existing ontologies
3. Enumerating important terms in the ontology
4. Defining the classes and the class hierarchy
5. Defining the properties of classes—slots
6. Defining the facts of the slots
7. Creating instances(individuals)

Determining the domain and scope of the ontology

In the first step of this methodology used for creating ontology, areas and scope of the application to be developed should be extensively discussed. When defining this domain, project is going to be used by whom, for what purpose and where it's going to be used, these declarations should be made, and then domain and area should be defined. Also, what questions this ontology is going to find answer and which problems it's going to solve should be defined in this stage. Some of the decisions, can be changed later, when developing ontology. This project aims to help teacher of the primary school 3-4-5-6-7-8 Science and Technology course, by creating concept maps using ontology, and also make student which takes the course understand the concept effectively.

Consider reusing existing ontologies

One of the aims for this project, is to prevent time loss when making concept maps in learning processes. As we said previously, the advantages to create ontology based concept maps in comparison to classic method based ones, is reusability. Due to this fact, before starting the creation process of an ontology, examining the resources about field to be made and if there are similar resources, instead of creating exact same, to think about expanding it. Sometimes, there are some ontologies may need to be imported to our own work. According to prior research it can be seen that there is insufficient scope in concept maps made with ontologies. Moreover lack of necessary inquiries and works done has not been put into place that can be easily be reached.

Enumerating important terms in the ontology

Concepts to be used in ontology, relation between concepts and properties of these concepts, without any distinction as lists should be documented. In this work, Ontology terms list are created using topics of Science and Technology course and terms needed when creating concept map of this subject's. In the next stage, with using this list, classes are inserted into a hierarchical order and concept properties were defined. Defining class hierarchy and concept properties is a nested process, thus, it made simultaneously. Some of the terms in ontologies can be added or changed in the creating process.

Defining the classes and the class hierarchy

There can be many methods used when determining class place order but the mostly used is the method Uschold and Gruninger (1996) mentioned in their work. These methods are defined as below:

> **Up-Down**: The development process starts from the upper class and continues towards lower classes. A path is followed from the most public class to the most private class.
> **Down-Up:** Starts the development process by identifying lower classes then by grouping upper classes are created. Follows a path from the private classes to the most public class.
> **Combination:** Ontology of the desired subject is defined as creating first and most striking concepts and making generalizations based on state privatizations.

In this study, since classes of ontology to be created are in a systematic list from upside to down, top-down method was deemed appropriate to proceed faster. If list of classes to be created is defined completely, using the general to the particular method provides convenience to the developer.

Defining the properties of classes—slots

Classes and hierarchical structure created, on their own do not show clearly the information to be given to desired audience. Semantic relations to specify the characteristics of properties and class definitions can be used in the ontology. There are two kinds of properties; Object properties and data properties. Object properties defines already created relationship between two classes, internal or external parts and the characteristics of the class.
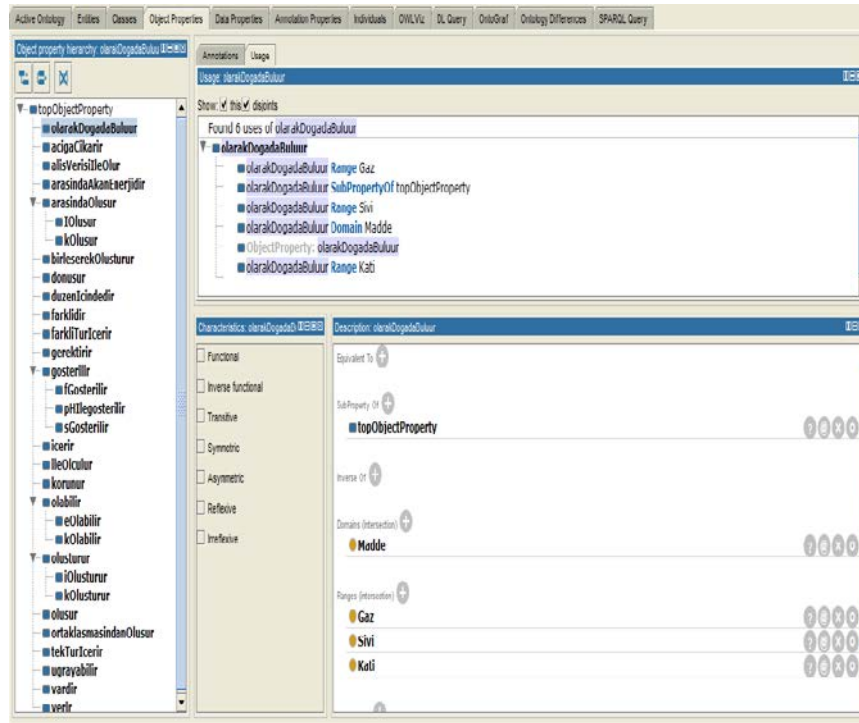

Figure 1: Showing of object attributes

For example in this study "isFoundInNature" property is defined. While the domain of this property is Material" class, range of this property are "Solid", "liquid and "gas" classes. If we look to this example as type of RDF trio, we can simply understand that: Substance can be found as solid liquid and gas in nature. (Figure 1)

Defining the facts of the slots

In this step, properties of attribution which defined in previous step are determined. These attribution may have value, value type, restriction and other properties.

Figure 2: Properties of Data property object

In this study, properties of substance and atom classes, values these properties can get and value types are defined (Figure 2).One of the properties of "atom" class is atom number.

Creating instances (individuals)

Last step of creating ontologies is to create individuals related to previously defined classes. The class which individual will be created should be selected, then individuals of that class will be created. There is not any limitation in individual number. Value type, values and restricts should be defined if there is any.
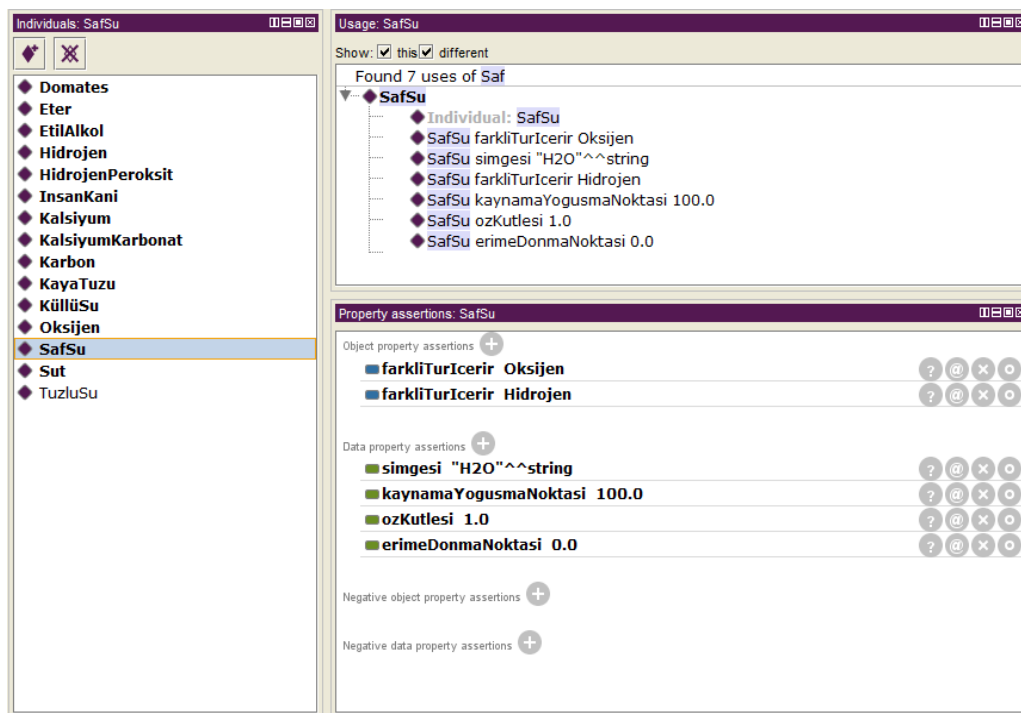

Figure 3: Individuals of classes and their values and restricts

Individuals related to classes "Atom" and "Substance" are defined in this study (Figure 3). Data property assertions and object property assertions of compound class are defined.

Query the Ontology in Web Environment

One of the greatest advantage of concept maps created using ontologies in comparison to concept maps created using classic methods, is that concept maps are written in a language that machines can understand, too. So the meaning of concept maps can be obtained as textual. This makes student's better associate previously learned concepts and new concepts, and makes meaningful learning active.

In order to make access of concept maps easier, they have been transferred to web environment. Users can examine concept maps of any science study subject using web environment and can make relevant queries on this subject (Figure 4) "Apache Jena Fuseki" has been used for transferring the created ontology to the web environment. Apache Jena Fuseki can give end-point (link) of loaded ontology. With help of this end-point, connection is established using language used in web environment. PHP is used for developing web environment. One of the reasons to prefer PHP is that both PHP and "Apache Jena Fuseki" can work on apache server without any problem. Also, another reason is PHP is open-source language. The interaction between PHP and "Apache Jena Fuseki" is achieved using "sparqllib.php" library of PHP. Using this library, queries in the SPARQL language are transferred to Apache Jena Fuseki Server and results are gained to store other needed data, MySQL database was preferred because of good compatibility with PHP.
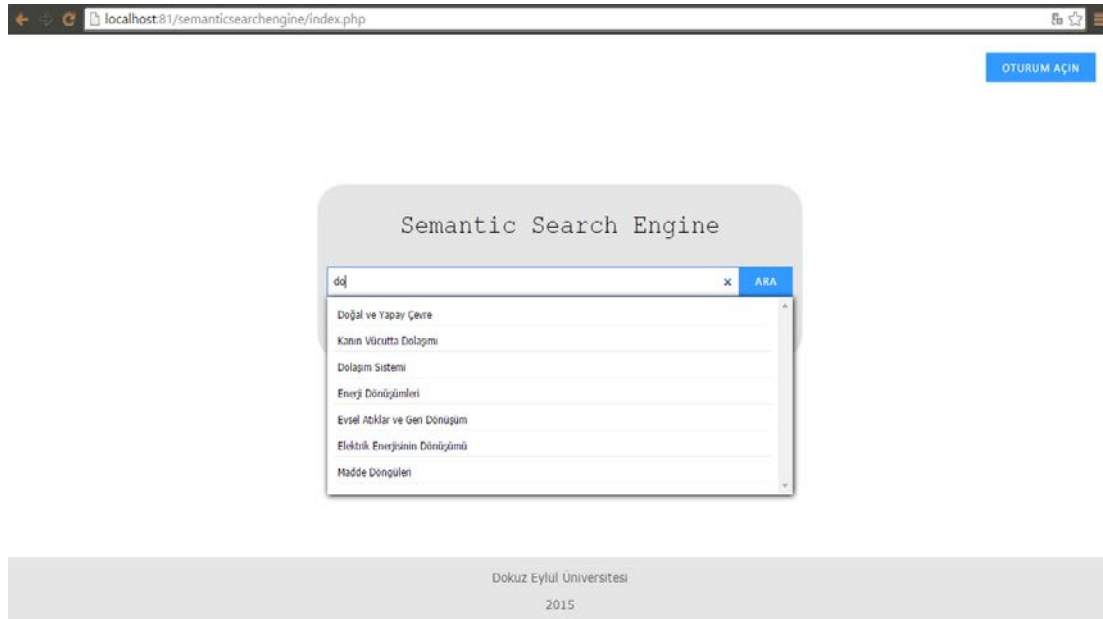
Figure 4: SPARQL query page of created website

Conclusion and Discussion

Since the emergence of the concept map, has been used by teachers as learning material actively. Concept maps establish meaning relationship by associating previous knowledge of students with new information. Also, it improves problem solving, analytical thinking and inferring cognitive abilities of students. However, concepts maps created using classic methods has some main problems. The first one is difficult and time-consuming process of creating concept maps using classic methods. When there is need to add new concept to map or change any concept in map, there may be need to recreate concept map. Concept maps created using classic methods have limited reusability. Also because of being created manually on paper it is difficult to store and archive. Nowadays rapid development of the computer usage in learning classical methods does not attract attention of students. So affective readiness of student decreasing.

Concept maps created using computers in comparison to maps created using classic methods have advantages. Concept maps designed using computers, show concepts in a hierarchical order. In addition the name of this concepts can be changed. The meaningful relationship can be created between concepts and more comprehensive maps in comparison to classic created concept maps (Baki & Mandacı Şahin, 2004, p.91). Moreover, in the process of creating concept maps gives the ability to save in any stage and continue later. When concept maps are used again, they can be found in computer environment easily and changed with respect to daily conditions in the manner of required technology. Also, improves update process and reusability functions.

Ontologies which are main structure of semantic web that came with Web 3.0 has similarities in structure with concept maps used as learning material. Concept maps created using ontology can be queried using SPARQL. This way get students attention to described of concept map on the desired subject. In this concept, ontology based concept maps are made with subject of science and technology courses in primary school curriculum, and queried in internet environment. In next studies, ontology based concept maps can be used in most subject and courses of primary school and provide meaningful learning. In addition to use ontology based concept maps as a teaching method, it can be used in the planning training and education, evaluation stages and correcting students previously learned wrong concepts.

Figure 5: A concept map created using protégé ontology editor

References

Adodo, S. O. (2013). "Effect of mind-mapping as a self-regulated learning strategy on students' achievement in basic science and technology," Mediterranean Journal of Social Sciences, vol. 4, no. 6, pp. 163–172.

Ausubel, D. P. (1963). The psychology of meaningful verbal learning. New York: Grune and Stratton.

Baki, A. & Mandacı Şahin, S. (2004). Bilgisayar destekli kavram haritası yöntemiyle öğretmen adaylarının matematiksel öğrenmelerinin değerlendirilmesi. TheTurkish Online Journal of Educational Technology (TOJET), 3(2). 91-104.

Berners-Lee,T. & Hendler,J. & Lassila,O., (2001). "The Semantic Web", Scientific American, vol.284, no:5, 34-43

Chu, K. K., Lee, C. I., & Tsai, R. S., (2011). Ontology technology to assist learners' navigation in the concept map learning system. Expert Systems with Applications, 38, 11293–11299.

Ergin,A.(1991). Eğitim Teknolojisi Tarihçesi. Ankara Üniversitesi Eğitim BilimleriFakültesi Dergisi , 24(2), 371-385.

Graudina, V. & Grundspenkis, J. (2008). Concept Map generation from OWL ontologies. The 3rd International Conference on Concept Mapping, September, 22-25, 2008, Tallinn, Estoniaand Helsinki, Finland, 173-180.

Graudina, V. & Grunspenkis, J. & Milasevica, S. (2012). Ontology merging in the context of concept maps. Scientific Journal of RTU, Vol. 13, 2012, pp. 29-36.

Grobelnik, M. & Mladenic, D. & Fortuna, B. (2009) Semantic technology for capturing communication inside an organisation. IEEE internet computing, 13:4, 59-66

Gruber, T. (1993). "Toward principles for the design of ontologies used for knowledge sharing", Technical Report KSL93-04, Knowledge Systems Laboratory, Stanford University.

Gültepe Y. & Memiş E.K. (2014). Kavram Haritalarının Ontoloji Tabanlı Oluşturulması: Kuvvet Konusu Uygulama Örneği. Journal of Instructional Technologies & Teacher Education Vol. 3, No.1,24-33.

Hsieh, Y.C., Lee, C.I. & Chu, K.K., (2013). Effect of an ontology-based reasoning learning approach on cognitive load and learning achievement of secondary school students. Pakistan Journal of Statistics, 29(5), 561-572.

Kaptan, F. (1998). Fen Öğretiminde Kavram Haritası Yönteminin Kullanılması. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 14, 95-99.

Novak, J. D. (1993). Human constructivism: A unification of psychological and epistemological phenomena in meaning making. International Journal of Personal Construct Psychology, 6, 167-193.

Novak, J. D. & Gowin, D. B. (1984). Learning how to learn. New York: Cambridge University Press.

Novak, J. D. & Gowin, D. B. & Johansen, G.T. (1983). The use of concept mapping and knowledge vee mapping with junior high school science students. Science Education, 67 (5) 625-645.

Noy, N.F. & McGuiness, D.L., (2001). Ontology Development 101: A Guide to Creating Your First Ontology, Stanford Knowledge Systems Laboratory Technical Report KSL-01-05 and Stanford Medical Informatics Technical Report SMI-2001-0880.

Silva, A. A. & Padilha, N. & Siqueira, S. & Baião & Kate Revoredo (2012). Using concept maps and ontology alignment for learning assessment. IEEE Technology and Engineering Education, Vol. 7, No. 3. 33-40.

Stutt, A. and Motta, E. (2004) Semantic Learning Webs, Journal of Interactive Media in Education - Special Issue on the Educational Semantic Web, 10.

Tekışık, H.H. (2002). Öğrenme-Öğretme Stratejileri. Çağdaş Eğitim Dergisi, 289, 1-8.

Uschold, M. and Gruninger, M. (1996). Ontologies: Principles, Methods and Applications. Knowledge Engineering Review 11.

Apache Jena official web site retrieved -01.08.2015- https://jena.apache.org/

Protégé official web site retrieved -15.06.2015- http://protege.stanford.edu/

World Wide Web Consortium official web site retrieved -10.06.2015- http://www.w3.org/RDF/

MySQL official web site retrieved -23.06.2015- https://www.mysql.com/

Hypertext Preprocessor official web site retrieved https://www.php.net/

Library of SPARQL download links – 05.08.2015- http://graphite.ecs.soton.ac.uk/sparqllib/