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Several Semantic Web Approaches to Improving the Adaptation Quality of Virtual Learning Environments

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Abstract: The aim of the paper is to investigate and propose Semantic Web approaches to improving the adaptation quality of Virtual Learning Environments (VLEs). These approaches are the method for semantic search for Web 2.0 tools in VLEs, and the method for curriculum mapping and semantic search for Learning Objects (LOs) in VLEs. In the paper, a special attention is paid to improving the adaptation capabilities of VLE, e.g. its suitability for different learning styles such as VARK. Web 2.0 tools ontology based on VARK model learning activities gives the possibility to develop adaptive learning environment with better access to specific learning content managing tools (i.e. Web 2.0 tools). The learner will only need to enter the name of learning activity into the search system field and the machine offers the appropriate tools to perform this activity. The engine facilitates the search process by optimizing workloads, thereby improving learner's satisfaction and improving the efficiency and effectiveness of the learning process. Presented curriculum mapping approach makes interoperability and LOs semantic search possible by making use of two smaller controlled vocabularies instead of a very large one on competencies which would be more volatile. One could exchange information on competencies in a multi-lingual and multi-cultural environment by: (1) breaking down competencies, and (2) relating these competency components to multilingual controlled vocabularies. The research results have shown that, in order to improve the adaptation quality of VLEs, it is very important to improve semantic search for both LOs and Web 2.0 tools in VLEs.

Keywords: Semantic Web; Virtual Learning Environments; learning objects; curriculum mapping; adaptation quality; learning styles
Categories: J.4, J.6, L.1.3, L.1.4, L.2.2, L.3.6, M.1, M.5

1 Introduction

The aim of the paper is to investigate and propose several Semantic Web approaches to improving the adaptation quality of Virtual Learning Environments (VLEs). These proposed approaches are the method for semantic search for Web 2.0 tools in VLEs, and the method for curriculum mapping and semantic search for Learning Objects (LOs) in VLEs. The practical problem analysed in the paper is how to improve the adaptation quality of VLEs using these Semantic Web based methods.

One of the more recent developments with the Web is an activity known as the Semantic Web (or Web 3.0). The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation [Berners-Lee 2001]. Two important technologies for developing the Semantic Web are XML and RDF. XML allows users to add arbitrary structure to documents without saying what these structures mean. RDF allows meaning to be specified between objects on the Web and was intentionally designed as a metadata modelling language. A third important aspect of the Semantic Web is a set of ontologies. An ontology is a specification of a conceptualization [Gruber 1993]. It describes the concepts and relationships of some phenomenon in the world. By using well-defined ontologies on the Web, it is possible for computers to meaningfully process data since there is a common understanding of terms used and the relationships between these terms [Mohan 2003].

The Semantic Web is concerned about the meaning of all kinds of information (such as LOs) on the Web. LO is referred here as any digital resource that can be reused to support learning [Wiley 2000]. LOs comprise an important subset of this information. Being able to reuse LOs created by others reduces the time and cost to develop learning content.

VLE is referred here as a single piece of software, accessed via standard Web browser, which provides an integrated online learning environment [Kurilovas 2010]. The main parts of each VLE are learning content (i.e. LOs) and Collaborative Web (or Web 2.0) tools. Therefore, in order to improve the (adaptation) quality of VLEs it is very important to improve semantic search for both LOs and Web 2.0 tools in VLEs.

In the paper, a special attention is paid to improving the adaptation capabilities of VLE, e.g. its suitability for different learning styles such as VARK. The acronym VARK stands here for Visual (V), Aural (A), Read/Write (R), and Kinaesthetic (K) [Fleming 2001]. [Fleming 2001] defines learning style as "an individual's characteristics and preferred ways of gathering, organizing, and thinking about information. It is focused on the different ways that we take in and give out information.

Evaluation is a process by which people make judgements about value and worth [Oliver 2000]. Quality evaluation is a systematic examination of the extent to which an entity (part, product, service or organisation) is capable of meeting specified requirements [ISO/IEC 1999]. Expert evaluation is a multiple criteria evaluation of learning software aimed at the selection of the best alternative based on score-ranking results [Kurilovas 2010]. The expert evaluation method based on the authors' MCEQLS (Multiple Criteria Evaluation of the Quality of Learning Software) methodology [Kurilovas 2010] is applied in the paper to evaluate whether application of the presented methods of semantic search of learning content and collaboration tools could improve the adaptation quality of VLEs.

The rest of the paper is organised as follows: methodology of the research is presented in Section 2, research results on semantic search engine for Web 2.0 tools in VLEs are presented in Section 3, research results on curriculum mapping and semantic search for LOs are presented in Section 4, evaluation results of VLEs adaptation quality are presented in Section 5, discussion is presented in Section 6, and conclusion and recommendations – in Section 7.

2 Research Methods

Research methods presented in the paper are the method for semantic search for Web 2.0 tools in VLEs, and the method for curriculum mapping and semantic search for LOs in VLEs.

In the paper, the original method of Semantic Search Engine (SSE) of Web 2.0 tools based on VARK learning style activities [Fleming 2001] ontology is presented. The aim of this method is to improve VLEs collaborative tools search and thus to improve the adaptation capabilities of VLEs.

As it was mentioned in the Introductory Section, three enabling technologies for the Semantic Web are XML, RDF and ontologies. Each of these has an important role to play in deploying and reusing LOs on the Semantic Web. XML is used to mark-up the structure of a LO in a machine readable way. It is also used to describe the metadata associated with LOs. RDF allows the specification of metadata and other information associated with LOs in a more flexible manner, facilitating the discovery and exchange of LOs with limited information or more than one metadata specifications. Ontologies allow the specification of concepts in a domain as well as the terms used to mark-up content in a LO. Shared ontologies allow for different systems to come to a common understanding of the semantics of a LO [Mohan 2003].

In the paper, the original method for curriculum mapping and semantic search of LOs is presented in more detail. The aim of this method is to improve learning content search in VLEs and thus to improve its adaptation capabilities.

Furthermore, the expert evaluation method based on the authors' MCEQLS methodology [Kurilovas 2010] has been applied to evaluate whether application of the presented methods of semantic search of learning content and collaboration tools could improve the adaptation quality of VLEs.

3 Semantic Search Engine for Web 2.0 Tools in Virtual Learning Environment

The aim of this Section is to present the method of Semantic Search Engine (SSE) of VLE collaborative (i.e. Web 2.0) tools based on VARK learning style activities ontology. This ontology is based on [Fleming 2001].

The goal of the adaptive VLE is increase its suitability for specific tasks, facilitate handling the system for specific users and so enhance user productivity; optimize workloads, and increase user satisfaction [Oppermann 1994]. Therefore, we can consider that the learner will be satisfied if he could manage learning content in a way convenient for him, and this possibility will be provided by suitable Web tools. According to [Fleming 2001], all learning styles could be divided into Visual (V), Aural (A), Read/Write (R), and Kinaesthetic (K). [Fleming 2001] reports that about 41% of the population who have taken the instrument online have single style preferences, 27% two preferences, 9% three, and 21% have a preference for all four styles. The aim of SSE method of Web 2.0 tools based on VARK learning style activities ontology is to improve VLEs collaborative tools search and thus to improve the adaptation capabilities of VLEs.

First of all, the following Web 2.0 tools (i.e. VLE communication/collaboration plug-ins) were analysed:

Ning, Elgg, WordPress	Social networks		Photos, images	*Picnik, Flickr, Photopeach, MugTug*
Yola, Wix, DevHub	Sites		Audio	*Spotify, Myna, Voicethread*
Blogger, Posterous, Blogas, Eblog	Blogs		Video	*Youtube, TED, Teachers.tv*
Slideshare, Zoho, Gloster, GoogleDocs	Presentations		Maps	*Bing Maps, Google Maps, Scribblemaps*
Twiki, Vikipedija, Wikispaces	Wiki	Managing Objects	RSS feeds	*Bloglines, GoogleReader*
Bubblus, Mindmeister, Mindomo	Mind maps		Animation	*Goanimate, Animote, Storybird*
Del.ico.us, Twine, Digg, BibSonomy	Bookmarking		Calendars	*GlideDigital, Kiko, Trumba*
Gapminder, Gliffy, Prezi, XMind, Xerte	Graphs, charts		ePortfolios	*Mahara, Exabis*
Scribd, GoogleDocs, Calameo	Files		...	...
		Web 2.0 tools		

Communication		
Text	Audio	Video
Adium, Skype, Messenger	*Skype, TeamUp, Voxopop*	*Skype, BigBlueButton, WebEx*

Table 1: Web 2.0 Tools

It was analysed that the majority of these collaboration tools are applied in the most popular VLEs such as Moodle. The problem is that it is quite different for the learner to identify all these tools while working in VLE, and use them in a proper way. A learner will be satisfied if he can manage learning material in the manner acceptable to him, i.e. using the appropriate Web 2.0 tools. For this aim the Web tools ontology based on activities that accommodate VARK learning style was designed. This makes it possible to develop the Semantic Search Engine (SSE) (Figure 1).

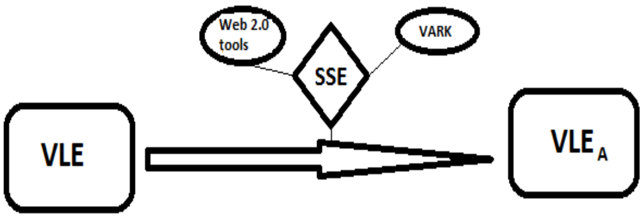

Figure 1: VLE improved by SSE of Web 2.0 tools based on VARK learning style activities ontology

Also, ontology gives the possibility to develop adaptive learning environment with better access to specific learning content managing tools (i.e. Web 2.0 tools). The learner will only need to enter the name of learning activity into the search system field and the machine offers the appropriate tools to perform this activity. The engine facilitates the search process by optimizing workloads, thereby improving learner's satisfaction and improving the efficiency and effectiveness of the learning process. The engine gives the possibility to move from "simple" VLE to VLE having higher adaptation level (VLE_A).

4 Curriculum Mapping and Semantic Search for Learning Objects

4.1 Topic – Goal – Activity Ontology

Semantic interoperability and reusability in comprehensive curricula-based education could be ensured if we could provide mechanisms where a meaningful entity in a country's curricula can be mapped to a meaningful entity in the other countries' curricula [Dagiene 2007].

The presented approach is based on the ontology created in [CALIBRATE 2008] project covering a common set of features for LOs and curricula. This is a three aspect classification model describing topic, goal and (learning) activity features (TGA). For curriculum analysis:

- The "T" refers to the topic of a part of the curriculum.
- The "G" refers to the desired level or competence that learners should obtain.
- The "A" refers to intended and prescribed learning activities by the pupils as part of the competence descriptions [CALIBRATE 2008].

The descriptions of students' learning activities, "A", are integrated parts of the goal/competence statements in the curricula. In general the "A's" are described by nouns expressions, e.g. to measure, to construct, to illustrate etc. To capture the semantic of curricula e.g. cross Europe one needs to classify them according to at least T, G and A. Other contextual factors to avoid ambiguity have to be presented in LOM profile [Dagiene 2007]. It is suggested to use topic and its sub- and related topics (e.g. Mathematics, Algebra, Geometry) to conceptually map a national curriculum.

However, this is not enough. While analysing the different national curricula, [CALIBRATE 2008] researchers have discovered that they also have competencies embedded and these are connected to certain learning activities. For the knowledge organisation system to represent a precise meaning of a curricula it must take into consideration both competencies and their implicit learning activities (e.g., four main concepts for describing goals in Mathematics curricula were identified: Acquire, Apply, Create and Participate (i.e. revised Bloom taxonomy); for each of the main concepts there are 4–9 concepts that are narrower in definition).

One could use Topic Map [CALIBRATE 2008] as a tool for navigating in the document structure, based on the semantic information contained in the document. Based on the tagging the systems could perform different types of queries based on the classification, and/or based on the different tagged information elements within a part of the document.

[CALIBRATE 2008] experts have chosen to represent the curricula document in XML, which also gives the possibility to use a vast amount of tools and applications for navigating and processing this information, there is a number of XML standards that would be useful. Since all the XML tools and the different formats for processing the curricula, and the curricula are in XML format, it will give us an advantage of reuse of tools and methodologies between the different "systems", since both Topic Map, RDF, SKOS and the curriculum have the same format. When one browses the curriculum using Topic Map, and selects a node, based on the semantic tagging of that part of the document, he should get a list of "Goal oriented words" and a list of "Topic oriented words" – based on the combination of this information and the TGA classification a set of LOs should be provided.

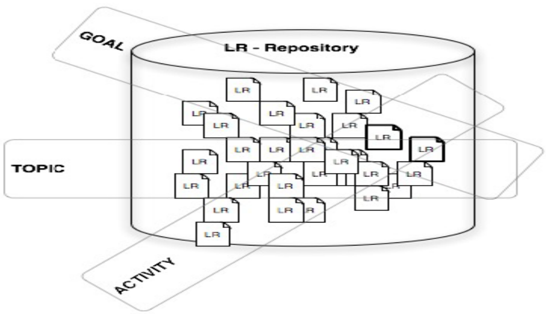

Figure 2: Search in LO repository / VLE using TGA ontology (according to [CALIBRATE 2008])

Identification of Goal oriented words could facilitate semantic enrichment, gives possibility for automatic searches in keyword, classification and description of LOs, and communities to annotate directly to Competency / Goal placeholders in the curriculum.

Identification of topic related words could facilitate communities to annotate relevant learning resources (LRs / LOs in repositories or VLEs) directly to the curriculum, more advanced searches, and more advanced browsing.

Lithuanian Mathematics curriculum for elementary and basic levels was chosen as a pilot for mapping in CALIBRATE, and it was mapped against learning goals in conformity with revised Bloom taxonomy.

4.2 Curricula Mapping: Problem Statement

While much progress has been made in improving semantic interoperability in order to discover, evaluate, and use LOs, teachers in primary and secondary schools in [CALIBRATE 2008] have constantly and consistently pointed to the requirement of being able to do this in terms of their national/regional curriculum. More in particular, given that a LO is properly metadata tagged using one national/regional curriculum, can the LO be discovered and can the metadata be shown to another teacher in terms of her own national curriculum, such that it eventually can be used in order to meet the goals of the teacher's national/regional curriculum?

[CALIBRATE 2008] experts consider mapping approach to be the most suitable for solving the problem. A mapping is provided between the different curricula such that if a LO is metadata tagged according to one curriculum, it can be discovered and shown in terms on another countries curriculum. A curriculum mapping means that a component of one curriculum can be mapped to a Boolean expression of components of another curriculum. This mapping can be done in two ways: relating all curricula pair wise to each other or relate all curricula to a common spine [Van Assche 2007].

Apart from the mapping challenge there is the question of relating curricula to educational content both for metadata tagging and for discovery. So essentially the challenge covered in section is threefold [Van Assche 2007]:

- How can we map curricula to each other? This deals with the semantic interoperability of curricula in order to avoid the tagging of LOs according to all existing curricula.
- How can we relate curricula to LOs? This in order to offer teachers to discover, evaluate and use LOs in terms of their familiar curriculum.
- How can we find LOs based on curricula and competencies?

4.3 Interoperability of Curricula

Curricula may contain a number of elements but the most important element is the set of educational goals. The best way to establish interoperability is to translate these goals into a common language. Obviously, if a goal can be broken down in smaller parts, the likelihood of finding common ground is higher than when using more complex goal expressions. In the presented approach, the authors favour competencies as the basic building block and this for two reasons: (1) it is easier to understand the targeted competencies behind an activity than the other way around; which indicates that competencies are more elementary, and (2) eventually learners will be assessed and this will usually be done by testing whether learners can solve problems requiring certain competencies.

While many definitions of competencies exist, this Section follows more closely the definition as used in the Learning Technology standardization world, i.e. as any form of knowledge, skill, attitude, ability or learning outcome that can be described in a context of learning, education or training.

Thus, the principle part of a curriculum is what students should learn expressed as targeted competencies.

The basic building blocks for targeted competencies are: an action verb expression and one or more topics. The topic might for example be “adding fractions” and the action verb expression might be “understanding” or “applying”.

As such competencies can be expressed as a tuple of the form $c = < v, \{t_1, \ldots, t_n\}>$ [12], where “c” stands for competency, “v” for an action verb expression and “$t_1, \ldots, t_n$” are topics [Van Assche 2007].

Usually there would be only one topic, but occasionally there will be more than one, e.g. in Lithuanian Mathematics curriculum: “to understand the relative size of the number and effect of arithmetic actions on the number” [Kurilov 2008].

The elements of the tuple come from two taxonomies: a topic taxonomy and an action verb expression taxonomy. Hence the problem of interoperability of curricula is reduced to the interoperability of these topic and action verb expression taxonomies and this is the key to the solution as it avoids a too complex spine to which curricula should be mapped. So the first step is to translate the goals of curricula into competencies. The relationship between the different taxonomies is given in Figure 3.

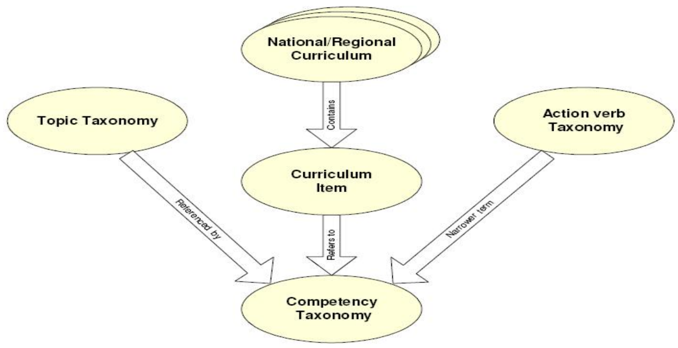

Figure 3: Relationships of curriculum items and taxonomies (according to [Van Assche 2007])

4.4 Lithuanian case study

In this Section, the authors use an example from Lithuanian Mathematics curriculum for elementary education: (1) Field (topic): positive numbers and actions therewith; (2) Essential abilities (goals): to understand the relative size of the number and effect of arithmetic actions on the number; and (3) Achievements (2^{nd} grade): (the learner) understands the sequence of natural numbers up to 100 [Kurilov 2008].

As one can see, the expression “understand” has narrower terms “understand the relative size” and “understand the effect of arithmetic actions”. Further refinements are possible by taking different action verb expressions for different topic categories. For example the action verb expressions for Mathematics could be different from the action verb expressions for languages. The second part of the solution is that competencies are referenced by terms in the Topic Taxonomy. For example "understand the relative size of the number and effect of arithmetic actions on the number" references the terms "numbers" and "arithmetic actions".

Semantic interoperability is thus achieved by first expressing curriculum items in terms of targeted competencies, and second by expressing these competencies as tuples of action verb expressions and topics which both can be drawn from a controlled vocabulary. The fact that two simple controlled vocabularies are used for expressing competencies allows for translation in other languages as well as automatic relaxing search criteria. If no LO could be found matching the competency "understands the sequence of natural numbers up to 100" then it could be relaxed to "understand the relative size of the number" climbing up the Topic taxonomy. Similarly it could be relaxed by climbing up the Action verb expression taxonomy. This relaxing mechanism also allows to map curricula even if there is no perfect match.

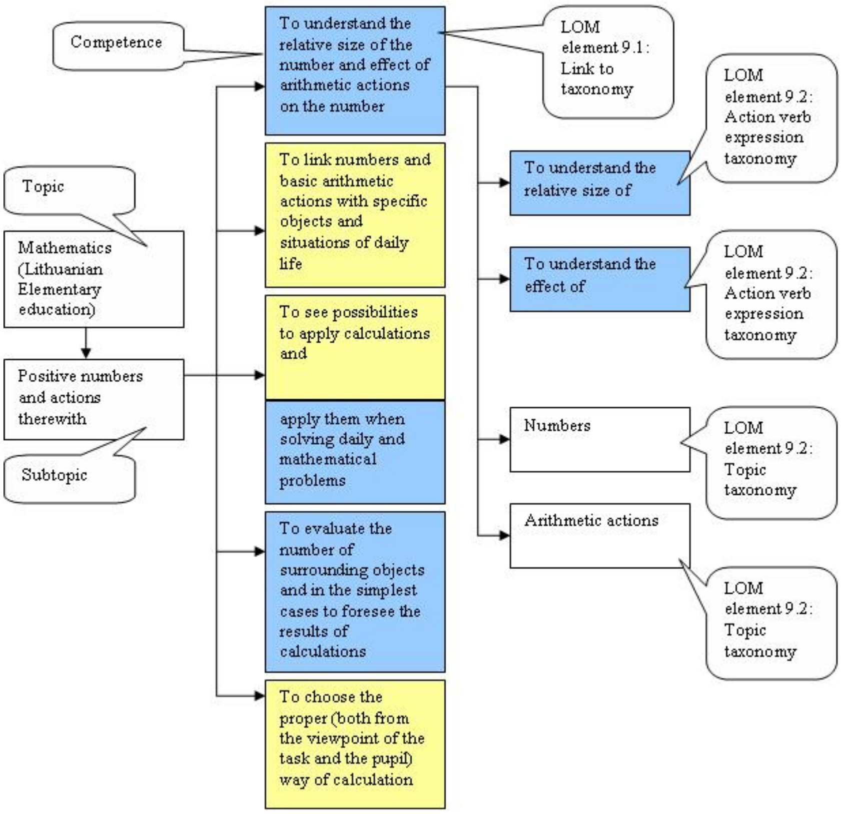

Figure 4: Example of curriculum mapping and relation with LOM (according to [Kurilov 2008])

The example of Lithuanian Mathematics for elementary education curriculum mapping and its relation with IEEE LOM standard [LOM 2002] is presented in Figure 4. In Figure 4, two main concepts for describing goals in Mathematics curricula are identified as “Acquire” (yellow colour) and “Apply” (blue colour). Two main concepts for describing goals in Mathematics curricula are identified as “Acquire” (yellow colour) and “Apply” (blue colour) [Kurilov 2008].

4.5 Linking Curricula to Content

Linking curricula to content can be done in two ways:

(1) An explicit relationship is established between a LO and a curriculum item, e.g. LO 72564 is said to be relevant for the curriculum item “the pupils are able to understand the relative size of the number and effect of arithmetic actions on the number”. More in particular, using concepts from set theory, the relationship is defined between a LO and the extension of a set of related curriculum elements. The extension of a set comprises the members of a set. Alternatively, the relationship is defined between a curriculum element and the extension of a set of related LOs. This can be done as metadata tagging of a LO or the curriculum element. For example a librarian or teacher indicates for which curriculum element the LO under consideration could be used. This may happen before or after discovery/evaluation, or use.

(2) The relationship between a curriculum element and a LO is defined by intension, i.e. the relationship is defined between a LO and the intension of a set of related curriculum elements. The intension of a set is its description of defining properties, i.e. what is true about the members of the set. The set of related curriculum elements could for example be described in terms of targeted competencies assuming that a curriculum element is suitable for the development of one or more competencies. A second way of establishing the relationship between a curriculum element and a LO by intension is that for a given curriculum element the properties of possible related resources are given. For example age, language, subject, targeted competencies of the resource. The properties that can be used for the describing a set of LOs and that are possible related to a curriculum element are: Keyword, Coverage, Structure, Aggregation Level, Interactivity Type, Learning Resource Type, Interactivity Level, Semantic Density, Intended End User Role, Context, Typical Age Range, Difficulty, Typical Learning Time, Language, Classification (purpose being discipline, competence, or activity). Again, establishing the relationship may happen before or after discovery/evaluation, or use.

In [CALIBRATE 2008], the experiment set up is linking a LO in an extensional way to a curriculum item or a competency. The way this is done is by giving the users the opportunity to browse the curriculum and indicate where a LO – e.g. identified through search or browsing – can be used. [CALIBRATE 2008] provided this opportunity to both curriculum experts as well as casual users such as teachers. By doing the latter, social tagging was introduced where the tagging process is guided through controlled vocabularies related to competencies. Hence teachers can indeed browse their own national/regional curriculum and find LOs that are useful in attaining the educational goals and to develop the underlying competencies.

The IEEE LOM standard [LOM 2002] is used for storing the metadata concerning competencies related to the curriculum. The competencies are stored in section 9.1 of the LOM where it is indicated that the classification concerns a competency and in section 9.2 where terms from an action verb multilingual thesaurus, and from a topic multilingual thesaurus are stored. Within [11], these two thesauri were developed. The action verb thesaurus according to Bloom's revised taxonomy and a topic thesaurus for the subjects Mathematics and Natural Sciences. The thesauri are multilingual thesauri and the competencies can be recorded also in a multilingual way.

5 Evaluation of Quality of Adapted Virtual Learning Environment

In order to evaluate the quality of VLE adapted by presented semantic search methods, let us apply MCEQLS methodology presented in [Kurilovas 2010]. According to MCEQLS, one should know VLEs quality criteria, their ratings (values) and weights [Kurilovas 2010].

There are some previous works where different sets of VLEs quality criteria have been analysed. In [Kurilovas 2005], the methodology presented in [Technical Evaluation 2004] was analysed to identify the VLEs technological quality criteria, and the framework presented in [Britain 2004] was analysed to identify pedagogical and organisational criteria of the VLEs quality.

In [Graf 2005], evaluation of open source e-learning platforms (i.e. VLEs) where the main focus is on adaptation issues was presented in more detail. Adaptation received very little coverage in e-learning platforms. An e-learning course should not be designed in a vacuum; rather, it should match students' needs and desires as closely as possible, and adapt during course progression. The extended platform will be utilized in an operational teaching environment.

In the authors' previous papers [Kurilovas 2009; 2011], a comprehensive model of the VLEs technological quality criteria was developed combining both general technological quality criteria developed in [Kurilovas 2005], and adaptation quality criteria developed in [Graf 2005]. According to [Graf 2005], VLEs adaptation quality criteria are adaptability, personalisation, extensibility, and adaptivity capabilities of the platforms.

There is a clear interconnection between SSE methods and VLE adaptation quality criteria. One of the effective methods to analyse if there are any interconnections between two sets is so-called Sets Portrait method. Let us use this method to analyse interconnections between SSE methods and VLE adaptation quality criteria. VLE adaptation criteria developed in [Graf 2005] are relevant to the aim of the presented paper, because they deal with VLE content and collaboration tools semantic search methods mostly. According to [Graf 2005], the VLE adaptation criteria are as follows:

- Adaptability: it includes all facilities to customise the VLE to suit the educational institution needs (e.g. the language or design).
- Personalisation aspects: indicate the facilities of each individual user to customise his/her own view of the VLE.
- Extensibility: in principle, it is possible for all open source products. Nevertheless, there can be great differences, e.g. a good programming style or

the availability of a documented application programming interfaces could be helpful.

- Adaptivity: it indicates all kinds of the automatic adaptation to the individual user's needs (e.g. personal annotations of LOs or automatically adapted content).

In order to establish the proper weights of the VLE adaptation quality criteria, let us use Qualitative Weight and Sum approach (QWS) presented in [Graf 2005]. QWS establishes and weights a list of criteria and is based on the use of symbols. There are six qualitative levels of importance for the weights, frequently symbols are used: (1) E = Essential; (2) * = Extremely valuable; (3) # = Very valuable; (4) + = Valuable; (5) | = Marginally valuable; and (6) 0 = Not valuable.

	Web 2.0 tools SSE	Curriculum mapping
Adaptability	+	+
Personalisation	*	*
Extensibility	+	+
Adaptivity	*	*

Table 2: Semantic search methods and VLE adaptation quality criteria sets portrait using QWS approach

Indeed, Personalisation (i.e. facilities of each individual user to customise his / her own view of the VLE), and Adaptivity (i.e. all kinds of the automatic adaptation to the individual user's needs) have direct extremely important impact on personalising one's learning in VLE by semantic search methods. In such kind of VLE, learners can customise some VLE features to match his/her learning style. Besides that, VLE could automatically adapt its own features incl. content and communication/collaboration plug-ins to match the requirements of the particular learning style. Therefore, these criteria are extremely valuable for particular learners' VARK styles.

On the other hand, VLE adaptability to suit the educational institution needs, and its extensibility have only indirect impact on learning personalisation possibilities.

The aforementioned MCEQLS quality evaluation method [Kurilovas 2010] used by the authors is represented by the experts' additive utility function (1) including the VLEs quality criteria's ratings (values) and weights:

$$f(X) = \sum_{i=1}^{m} a_i f_i(X) \qquad (1)$$

Here $f_i(X)$ is the rating (i.e. non-fuzzy value) of the criterion i for the each of the examined VLEs alternatives X.

The major is the meaning of the function (1) the better is the VLE alternative.

One could notice that while comparing the same VLE before and after application of SSE methods, both weights and ratings (values) of VLEs personalization and adaptivity criteria will increase, thus making the value of the function (1) major. Therefore, the adapted VLE where presented semantic search methods are applied is more qualitative in comparison with the same VLE before application semantic search methods.

6 Discussion

The proposed methods for (1) VARK ontology based semantic search for Web 2.0 tools in VLEs and (2) curriculum mapping and semantic search for LOs are applicable semantic search methods based on HML, RDF and ontologies.

There are number of research results on learning personalisation topics published in scientific literature during the last years, e.g. [Bennane 2013], [Kim 2013], [Dorca 2012], [Lubchak 2012], [Beres 2012], [Hadjerrouit 2012]. But there is still a lack of research on using Semantic Web for intelligent semantic search of the VLE content and services/tools suitable for the particular learning styles. If there should exist the qualitative technologies for semantic intelligent search of the relevant learning content on the Web, the learners should get the additional possibility to use this suitable content in their VLEs.

On the other hand, there is a lack of the research on personal learning environments suitable for different learning styles.

Therefore, research on future Semantic Web and personal learning environments should be the core research trends to improve personalisation aspects and automatic adaptivity of VLEs.

7 Conclusion and Recommendations

Presented methods for (1) VARK ontology based semantic search for Web 2.0 tools in VLEs and (2) curriculum mapping and semantic search for LOs in VLEs are suitable to increase the adaptation quality of VLE.

VARK ontology gives the possibility to develop adaptive learning environment with better access to specific learning content managing tools (i.e. Web 2.0 tools). The learner will only need to enter the name of learning activity into the search system field and the machine offers the appropriate tools to perform this activity. The engine facilitates the search process by optimizing workloads, thereby improving learner's satisfaction and improving the efficiency and effectiveness of the learning process. The engine gives the possibility to move from "simple" VLE to VLE having higher adaptation level.

Presented curriculum mapping approach makes interoperability and LOs semantic search possible by making use of two smaller controlled vocabularies instead of a very large one on competencies which would be more volatile. One could exchange information on competencies in a multi-lingual and multi-cultural environment by: (1) breaking down competencies, and (2) relating these competency components to multilingual controlled vocabularies. The approach builds on proven technologies, i.e. thesauri, and well-known vocabularies for the action verb expressions and allows for relaxing the search criteria building upon the hierarchical structure of the two vocabularies. The approach can be used for tagging by experts indexers as well as for social guided tagging where the guidance comes from the multilingual thesauri provided. The approach is resilient to change in curricula and to the addition of new curricula. Even a teacher could determine her year plan and be automatically interoperable as long as the year plan is specified in terms of tuples (indicating competencies) of action verb expression and topic(s) which are a subset of the

Cartesian product of the terms in the two vocabularies: topic and action verb expression. The approach fits very well with the current practice of describing LOs. Indeed, section 9 of the IEEE LOM standard can be used without alteration. For LOM data element 9.1, indicating the purpose, the value "competence" should be used. One condition to be fulfilled is that curricula are expressed as competencies, which is not always the case. Sometimes they are expressed as activities to be undertaken or simply as subjects to be taught. In that case the targeted competencies should be researched or interoperability can be restricted to the topic vocabulary. Curriculum mapping recommendations are as follows: (1) not one big competency taxonomy but two smaller vocabularies, (2) more resilient to change; (3) using proven technologies – thesauri (subject, revised Bloom); (4) possibility for relaxing the search: the results of the proposed method are substantially better in comparison with the method of trying to find LOs suitable for developing the same competencies with Google.

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