Multilingual ontology-based knowledge model for e-learning resources delivery

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Abstract— multilingual ontologies are needed to ensure flexible access to the multilingual data and other language-dependent resources by the users. Resent researches show that multimodal learning, that uses miltilingual resources is more effective than traditional uni-modal learning. In this paper we present a short survey of the approaches to develop multilingual ontologies and its usage in the e-learning. We seek the reasons for low research interest to the usage of multilingual ontologies in e-learning and propose the knowledge model that will clarify the need of multilinguality in e-learning and will simplify usage of multilingual ontologies in this area.

Index Terms — e-learning, ontology, multilingual ontology, knowledge modeling, ontology translation, ontology mapping, e-learning content retrieval.

1 Introduction

Learners from the entire world are needed of the good learning resources, having actual content and written in his native language. On the other hand, there are many good resources for learning in the learning repositories (as MERLOT [1] and ARIADNE [2].), as well as many cites and tutorials in the internet, but most all of them are written in English. Some learners can read English-written learning content, but it is difficult for them to find the best one because of the language-related difficulties (it is difficult to write the exact search query in foreign language). CISCO researchers [3] have proved that multimodal (including multilngual) learning is more effective than traditional uni-modal learning. So, effective, easy to use and well working tools for query refinement and translation into English are needed to support multilingual e-learning resource retrieval. High quality language resources as Simple vocabularies, Thesauruses, Dictionaries, glossaries and Ontologies are used to support automated multilingual information searching and retrieval [4].

E-learning domain is complex and rapidly evolving. A lot of information is needed to ensure high-quality learning content delivery: the one, specified in e-learning standards (i.e., IEEE LOM and IMS-LD); information for description of LO structure, including low-granularity of a LO; information, supporting learners' evaluations about usefulness of a specific content unit; information about other e-learning context specifics [5]. Semantic modeling of all this information by usage of multilingual ontologies will guarantee the best search and retrieval quality. Many projects, related to ontology usage in e-learning have been developed in the latest years. Most of them report good results, but almost all experiments are performed by usage of English language labeled ontologies and in the Most of the ontologies, developed by Bulgarian authors and covering specific Bulgarian domains also use English language terminology. For example, [6] presents ontological model of the Bulgarian folklore knowledge, including the semantics of context of learning in English language-represented content, the phenomena of Bulgarian traditional culture, but all the labels in this ontology are written only in English language. So, this Bulgarian folklore domain ontology is also using lexical items only in English and will not be usable in applications that work with Bulgarian terminology.

The aim of this paper is to analyze existing approaches for knowledge modeling in e-learning domain, as well as approaches for development and usage of bilingual or multilingual ontologies in e-learning and answer the question "How we can ensure or stimulate inclusion of Bulgarian language terminology as an obligatory element of ontology development, evolution and maintenance process to support e-learning resources delivery both for Bulgarian and English language written resources?".

We will present an approach for semantic modeling of knowledge in e-learning domain, based on bilingual or multilingual ontologies that can support effective delivery of e-learning resources, written in all the used languages.

2 Existing techniques

We will make short analysis of two main type technologies, related to our research domain: for knowıɪɪledge modeling by usage of multilingual ontologies and for knowledge modeling in e-learning domain.

2.1 Knowledge modeling specifics in e-learning domain

E-learning domain is a complex domain that typically contains knowledge about:

- Learning content;
- E-learning theory-related metadata, including:
  - E-learning content structure;
  - E-learning context;
  - Learning and teaching approaches;
  - E-learning design;
  - Learner profile.

Many different models and theories are created and tested in the e-learning area in correspondence with various learning approaches and used technologies. A Short overview of the different types of eLS is presented in [7]. E-learning systems classifications are based on different criteria, as instructor's role, delivery method, or technology and tools used. Accord-

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ing to the main role of learners there are Instructor-led e-learning approaches and Self-paced approaches. Instructor-led systems can be done using virtual classrooms and Self-paced systems are these in which a learner determines the place and timing of content delivery. According to the Used Technology there are Distributed/Distance learning systems, Mobile learning systems, Blended learning systems, Game-based learning systems, Social learning systems, personalized learning systems. All these type systems have some level of standardization and its specifics. Distributed/Distance learning is based on the delivery of educational resources from the different place usually by usage of computer networks. Mobile learning for example is any sort of learning that happens when the learner is not at a fixed, predetermined location and is based on usage of iPod, portable PlayStation, or Mobile phones. Social learning is based on collaboration and discussions for solving problems, queries, and sharing experiences usually over networks. Social collaboration platforms are usually built within the LMS. E-Learning 2.0 is based on the use of Web 2.0 concept, which is read and write web with its applications e.g. social networks, blogs, wikis. Personalized learning tailors the pedagogy, curriculum and learning environments to meet the needs, preferences and learning styles of individual learners. Game-based learning meets the needs and learning styles of individual learners. Blended learning is a combination of offline (face-to face, traditional learning) and online learning. There are also learning materials, adapted for specific groups of learners, as for children, adults, learners with some learning disability (as dyslexia, dyscalculia). So information about specifics of different type e-learning is important in the searching of e-learning resources.

The most frequently used e-learning content is described by usage of Learning Management Systems (LMS) and meets clearly specified e-learning standards. Widely used standards are SCORM (Sharable Content Object Reference Model), AICC, which supports secure information transfers with HTTPS, Experience API, IEEE LOM.

Despite of the standards, metadata, used in the e-learning systems strictly depends from the underlined learning approaches, goals, used tools, etc. That is who semantic modeling of pedagogical and domain knowledge in every e-learning system and mappings between models are need for ensuring learning objects reuse between learners and systems.

Many works have been published recently in the e-learning community that uses ontologies for modeling various knowledge sets in e-learning systems. Ontologies are used for modeling pedagogical knowledge, technological metadata, learners capability and behavior, learning styles, prefer

The ALOCOM ontology for example presents an abstract content model for documents and their components [8]. It defines content component at different levels of granularity and relationships between components and uses metadata to describe some general features of learning domain, needed for searching of learning resources.

The LOCO (Learning Object Context Ontology) [9] is an IMS-LD-based ontology. It provides an ontological framework that can be used for the development of Semantic Services as "learning designs" using the ALOCOM ontology learning objects representation.

Unit of learning ontology for organizational units of learning based on IEEE LOM standard is presented in [10]. A Unit of Learning contains terminology of the course structure and the set of resources (related both to Learning Design, and to Content Package).

An ontological model for the representation of teaching domains is presented in [11]. It integrates pedagogical resources descriptors and semantic annotations that can be used by learning by doing systems to execute different learning activities and to connect resources anywhere through the Web.

Many projects related to intelligent tutoring or personalized learning use learner profile ontology. Dynamic Learner model ontology for example is presented in [11]. This paper also presents a strategy that allows content adaptation to students in VLEs, using multi-agent system technology manipulating an open learner model ontology comprised of several learner characteristics, such as their competencies, skills, equipment which the learner uses, performance on activities, frequency and learning styles. The leaner model is dynamically changed during the course, through the interactions of the student with VLE.

As a conclusion, attempts to develop ontological models of all the knowledge components in various e-learning system types are made. However until now, there have been no significant practical results about the impact of automated reasoning for improving learning quality. The best reported results are related to usage of domain ontologies for document retrieval, annotation and construction.

Almost all ontologies used in e-learning projects use labels, written in English. For supporting learning or searching of learning content for users, having other mother language ontologies, having labels, written in this language are needed. So, in the rest of this paper we will discuss how to find or develop ontologies, having labels in two or more natural languages (bilingual or multilingual ontologies), or how to build multilingual ontological systems, needed for supporting internationalization process in e-learning.

2.2 Knowledge modeling by usage of multilingual ontologies

The features of multilingual ontologies, methods and techniques that are used to create multilingual ontologies are analyzed in [12]. Six techniques that are used to create multilingual ontologies are discussed in [12]: Matching the ontologies, aligning the ontologies, Mapping the ontologies, Creating Ontology library file, Ontology localization, Translation of ontology labels.

Creating multilingual ontologies using a library file is presented in three steps [13]: Creating a plain text file containing all terms from the central Ontology; Translating the terms to other language; creating a new Ontology in other language.

After comprehensive literature analysis we classify approaches for building bilingual or multilingual ontologies in the following categories: Manual approaches; semi-automatic and automatic approaches. Manual development can ensure high-quality of the developed ontology, but requires many human experts' efforts and this is very expensive, and in some cases leads to subjective representation of the modelled do-

main. Automated development has insufficient quality, so most of well-working approaches are semi-automatic. These approaches can be based on Information Retrieval, Machine translation, ontology mapping, Controlled Natural Languages (CNL).

A language-independent, corpus-based method using information retrieval and machine translation techniques for creating bilingual ontology have presented in [14]. It shows that there exists an efficient algorithm that is capable aligning ontologies with two very different language structures, as Chinese and English. This method uses word contexts from a large bilingual corpus.

Semi-automatic approaches use textual or linguistic resources and machine translation or ontology-mapping techniques. Web-based resources as Wikipedia, online thesauruses or dictionaries are frequently used. Easy-to use tools as Semantic Wiki tools as OntoWiki, and collaborative platforms for management of diversity in language and knowledge across cultures, as such, proposed in [15] can support semi-automatic collaborative development of multilingual ontologies.

A graph based Core Ontology Construction Algorithm (COCA) to automatically construct core ontology from an English-Chinese bilingual term bank has proposed in [13]. The used algorithm uses WordNet and upper-level Suggested Upper Merged Ontology (SUMO).

Two main technological approaches are used during creating multilingual knowledge models: label translation of previously – developed in some language (most frequently English), and development of independent ontological models of one and the same domain in different languages and then mapping these ontologies.

Net project [16] (EuroWordNet) for example consists in building language-specific WordNets independently from each other, and trying in a second phase to find correspondences between them. As adding multilingual information makes ontologies bigger and it's querying - slower, some resent multilingual ontology – development approaches are oriented to develop small multilingual ontologies (covering specific domains) and create mappings between these and upper level ontologies, containing more general terminology [17]. Two main strategies for ontology mapping are used for mapping of ontologies that are created in different languages: direct alignment and indirect alignment. The direct alignment strategy considers direct matching between two ontologies with the help of external resources. The indirect alignment strategy is based on composition of alignments. Semi-automatic (suggestion-based) mapping [18] is frequently used.

A system, named LabelTranslator, that automatically localizes ontologies, is proposed in [19]. LabelTranslator takes as input an ontology whose labels are described in a source natural language and automatically obtains the most probable translation into some target natural languages of each ontology label. To do this, the system uses a translation service from/into English, German, or Spanish based on linguistic resources such as lexical databases, bilingual or multilingual dictionaries and thesauruses (as EuroWordNet GoogleTranslate, Wiktionary) and terminologies.

One of the main reasons for the low translation quality is the natural language ambiguity. Many domain-specific lexical elements can be ambiguous as language elements, but are not ambiguous in fixed domain. For example, the term "ontology" is ambiguous, as it is used in philosophy and computer science, but in every one of these domains it is clearly defined. There are also terms, which are ambiguous in its specific domain. Examples of ambiguous terms in computer science domain are the terms header, word, port, point. They have more than one meaning in this domain.

The main problems, related to the usage of lexicons are related to:

- Higt polysemy, which induce problems in automation of ontology learning and mapping.
- Low coverage. Some domain-specific words do not exist or some domain-specific senses (as ontology learning) are not presented in lexicons

Ontology translation web service system [20] (http://server1.nlp.insight-centre.org/otto/rest_service.html) can translate ontology labels from English into German, Spanish, Italian, Irish, Slovenian and Czech. The results are accessible trough an html table, csv or json file, multilingual hed ontology or in a multilingual ontology in lemon. This service does not support translation to Bulgarian. There are several other projects, related to ontology translation but we do not find any other services, projects or systems for ontology translation into Bulgarian.

2.3 Multilingual ontologies in e-learning

We have found some projects that attempt to translate e-learning standardized metadata and some domain ontologies, used in e-learning. Translating the terminology, used for description of e-learning standards into various languages (including Bulgarian) is of great importance for searching and retrieval of learning content in two or more languages. Many Bulgarian learners for example can use Russian or English language –written resources, and these resources usually are of higher quality than these, written in Bulgarian. Multilingual ontological systems will be very useful for supporting searching and retrieval of the best learning resources in this context.
Attempts to translate the LOM conceptual data schema (element titles and vocabulary values) into a variety of European languages is presented in [21] Most of these translations have not been made publicly available in finalized form. The idea that the original English versions of these names and values should be regarded as linguistically neutral and equivalents in alternative languages should be provided through the user interface or any other mechanisms is proposed in [21] and widely accepted.
The problem of automatic indexing of online educational resources is discussed in [22], [23], and an approach to help the indexing operation by automatically extracting a set of relevant terms describing the educational content of a resource is proposed in [22]. This approach is based on the TF-IDF algorithm, the usage of a domain lexicon and exploits the structure of educational documents. It also have proposed semantic ontology-based model for multilingual indexing and retrieving the educational resources in a web learning environment. This model has been implemented through the development of a

web learning portal prototype. This prototype is used to perform trilingual searching (Arabic – English – French) for online learning resources. The model uses Learning Domain Ontology (LDO) and is tested for indexing a database of learning resources related to the Object Oriented Programming in Java. Mapping techniques are also used.

[24] Uses for LO annotation domain ontology represented in a Simple Knowledge Organization System (SKOS), containing about 1700 concepts. These concepts were translated semi-automatically by providers of educational content with the help of machine translation into French, Spanish, German, Italian Lithuanian languages

BONy [25] is a cognitive mobile e-Learning Management System (LMS) that supply a multilingual access to information by ontological representation of knowledge and an interconnection among learning objects accordingly to Semantic WEB methodology, best practices and standards. Italian, English, Spanish, Greek, German, Polish, Hungarian, Slovakian Czech and Catalan languages are involved.

Multilingual ontology for e-learning is developed in [26] by translation of English monolingual domain ontology semi-automatically by providers of educational content with the help of machine translation into 5 languages (French, Spanish, German, Italian and Lithuanian). This multilingual ontology is used to annotate textual content of LOs. In such a way the multilingual ontology is used for ensuring sharing and reuse of learning resources.

As we have found just a few papers, describing research on multilingual ontologies in e-learning, we were motivated to answer the question "How many papers on this topic have been published in the internet?"

We have sent queries to Google Scholar fixing publishing year between 2004 and 2016. The number of returned results is shown on the charts bellow (fig 1, fig. 2, fig 3.).

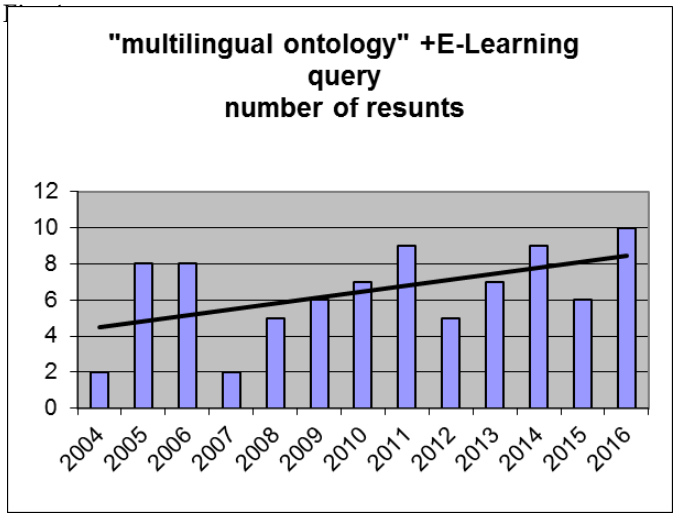

Fig. 1. Number of resources, returned by Google Scholar as a response of the query "multilingual ontology" + e-learning

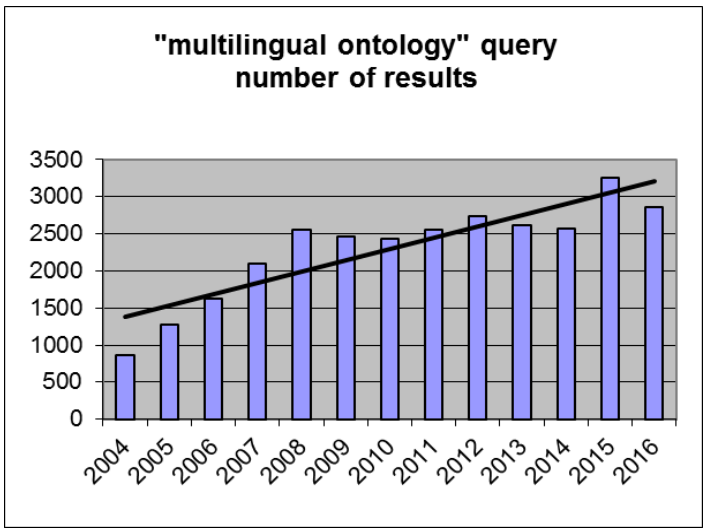

Fig. 2. Number of resources, returned by Google Scholar as a response of the query "multilingual ontology"

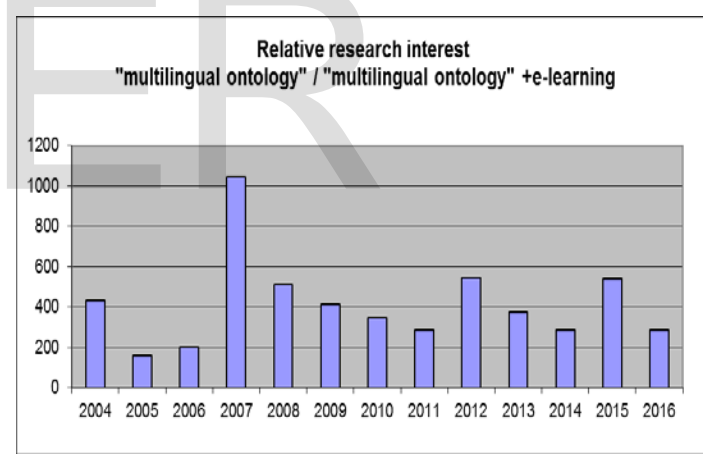

Fig. 3. Relative researchinterest by Google Scholar
"multilingual ontology / ("multilingual ontology" + e-learning)

The charts show very little research interest in usage of multilingual ontologies in e-learning. On the other hand, there is relatively big and fastly growing scientific interest in multilingual ontologies (fig. 2). In our view, the main reason for this little research interest in usage of multilingual ontologies in e-learning is because of the fact that multilingual ontologies are very young research area, and significant prractical results from ontology usage in e-learning are expected in the future.

We will propose the knowledge model that will clarify the need of multilinguality in e-learning and will simplify usage of multilingual ontologies.

3 The Semantic Model of Learning Organizational and Repository Metadata Representation

In LO repositories learning objects, LO templates ontologies and semantic relations for LO annotations can be stored, and ontologies are used for semantic representation of annotation metadata. Repositories follow a series of specifications and standards, which enable interoperability with other repositories, and ontologies, are the best tool for such interoperability. One of the most frequently used specification for metadata in E-learning resource repositories is IMS Digital Repository interoperability specification (IMS DRI) Learning Object Metadata is a data model, used in IMS DRI that describe a learning object and similar digital resources used to support learning. For resource Organization IMS RLI (Resource List Interoperability) standard is used, and for Packaging - IMS CP (Content Packaging) standard. Sharable Content Object Reference Model (SCORM) is another collection of standards and specifications for web-based e-learning. AICC HACP and Dublin Core are also standards, used for describing e-learning resources.

Apart from e-learning content, described by standardized metadata, many tutorials, e-books or web sites, useful in the learning process can be found in the internet. Our aim is to develop knowledge model, that will support effectively searching and retrieval not only of the metadata described e-learning resources, but all useful for learning resources in the internet.

Having in mind complexity and diversity of e-learning metadata, needed for searching learning content, and translation difficulties, we believe, that it is important to divide all this knowledge in two main categories: knowledge, which can be used in English language, and knowledge, that must be translated in all the languages, in which learners search the learning content. So, in this work we present the ontology-based knowledge model for retrieval and search of multilingual learning resources, in which the language-independent knowledge is clearly separated from the knowledge, needed to be translated in every language, used in the searching.

We use the following guidelines: the terminology, that learner need to use in the search process, needed to be translated. All the knowledge, used internally by the searching system can be leaved only in it's English language representation.

All domain knowledge, represented by domain ontologies must be translated in everyone of the used languages, as learners will use these terms in searching process. Many learning domains, as Mathematics and Computer science have the same knowledge model in different languages. The multilingual ontologies, modeling these domains can be developed by usage of label translation approach. Semi-automatic translation can be used. After linguistic resource or corpus-based translation experts or students should accept or reject the translation proposals. Other domains, as such, related to national language and culture, have different knowledge structure for different nationalities. These domains should be represented by development of different ontologies in different languages, and then map developed ontologies.

As more and more resources become available in more than one language, and usage of bilingual recourses is useful for learning in many domains, novel algorithms, which are capable of matching ontologies in bilingual or multilingual context, are needed. Matchings can be performed between ontologies, which share more than one language, or ontologies which are multilingual but do not share any languages (language – independent ontologies). In [27] several approaches for using multilingual information to improve the matching quality are analyzed in cross-lingual and multilingual scenarios. Cross-lingual matching is performed mainly by a translation services. The mapping approach presented in [27] uses machine learning techniques and cross-lingual information to perform both multilingual and cross-lingual matching. A set of manually matched concepts is used to train on machine learning algorithm for learning the matching function.

As the internationalization of e-learning standards does not ensure terminology translation into natural languages, different from the English language, and the translation requires many efforts and expert knowledge, we will carefully separate the E-learning standards terminology to two main classes: global terminology, useful for linking different standards, and sometimes used by learners in searching; and specific for the concrete standard terminology, that is used only internally by the searching engines. The first (global) terminology should be organized in Global multilingual learning metadata ontology, and the second class – in ontologies, describing internal specifics of the standards that should be mapped to global ontology.

So, we propose the knowledge model for searching and retrieval of multilingual learning content that consists of two main components (fig.4):

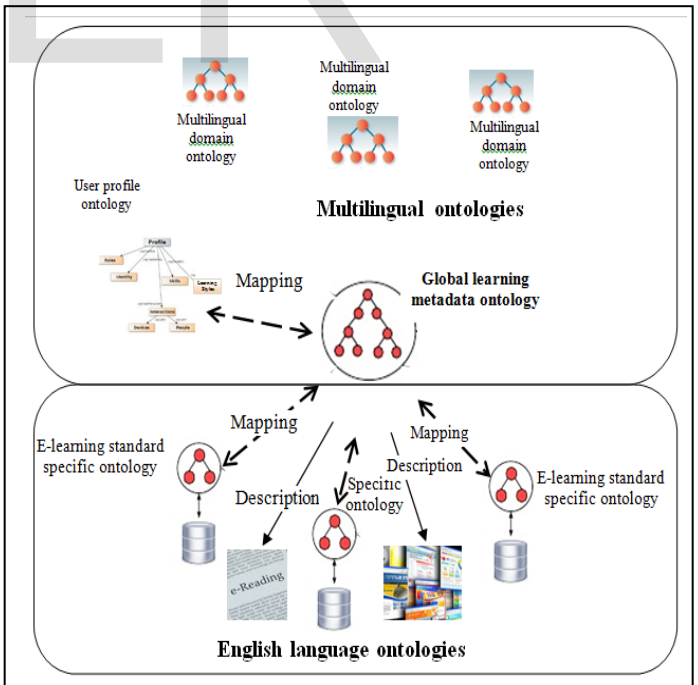

Fig. 4. Knowledge model for searching and retrieval of multilingual learning content.

- English language labelled ontologies

- Multilingual ontologies.

English language labelled ontologies is ontologies, describing internal specifics of the e-learning standards

Multilingual ontologies are:

- Global learning metadata ontology
- Learning Domain ontologies
- Learner model ontology

4 Expected results

Almost all developed and freely available ontologies (including these in e-learning) use labels in English language. Manual translation requires expert knowledge and many efforts and is very expensive. Automated translation approaches usually have insufficient quality. Our model shows, that significant amount of knowledge (related to e-learning standards and metadata) can be used in its original English language representation, as it is language-independent.

The model also will ensure E-learning standards interoperability by usage of Global learning metadata ontology and its mappings with learner ontology and ontologies, describing internal specifics of the e-learning standards.

In Global learning metadata ontology we organize Standardized metadata, that are important for all the e-learning standards, or are used directly by learners in searching, should be organized in ontologies and translate them in multiple languages. Usage of this ontology and learner profile multilingual ontology in the query refinement will ensure effective retrieval of the most appropriate for the learning goals resources, written in two, three or more languages in correspondence with user learning styles and preferences.

Multilingual domain ontologies, labeled in multiple languages will ensure delivery of the best available and usable by the learner resources. In such a way our model will simplify the efforts for organization of knowledge for searching multilingual resources and ensure higher learning quality by supporting learning in multilingual web-based environment.

The model will be the most useful for learners from small countries, which native language is not widely used, because of the fully absence of ontologies, translated in its language, insufficient linguistic and learning resources written in these languages.

5 Conclusion

In this paper we propose a knowledge model that clearly separates the knowledge, needed for organization of multilingual learning in two categories: language-independent knowledge and knowledge that must be translated or represented in every used language. The discussed usage context of our model is searching and retrieval of multilingual learning content. The model will be the most useful for learners from small countries (as Bulgarian learners), which native language is not widely used and e-learning resources in his native language are not sufficient.

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