VILNIUS UNIVERSITY

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RESEARCH ON WEB 2.0 TECHNOLOGIES IN EDUCATION

Summary of Doctoral Dissertation
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1. GENERAL CHARACTERISTICS OF THE DISSERTATION

1.1. Scope and Relevance

Personalised e-learning systems deal with appropriate personalisation techniques in order to maximise the effectiveness of learning. Personalised e-learning is an important research area of modern educational technology. At present, total utilisation of computer techniques to implement the personalised learning is very difficult. There are plenty of Web 2.0 technologies and examples of their use in education. Most of the researches focus on e-learning systems personalisation functionalities such as personalised learning plans and learning materials. Although in practice and in many sources of literature the need for the application of Web 2.0 tools in education is highlighted, however there is lack of clear methods how these tools could be applied in learning for a higher learning quality and there is a lack of e-learning systems that implement these methods. Also, these tools are not always suitable for the task to which they are applied and they are not always properly used for a specific purpose. Furthermore, most of the e-learning systems are focused on the course rather than on the learner, which means that they do not satisfy one of the final learning stakeholders.

In order to address these problems, learning environments must be more adapted to the learner. To this end, learning is personalised.

We propose to provide a higher learning quality by developing a knowledge-based recommender system prototype. This system gives a possibility to develop personalised learning environment with better access to specific learning content managing tools (i.e. Web 2.0 tools). Thus it facilitates the search process by optimising workloads, improving the learner's satisfaction thereby as well as the efficiency and effectiveness of the learning process.

1.2. Research Object

Research object of the Doctoral thesis is usage of Web 2.0 technologies for learning personalisation.

1.3. Aim and Objectives

The aim of the doctoral thesis is to present the personalised Web 2.0 tools selection method taking into account the learner's learning preferences for content and communication modes tailored to the learning activities with a view to help the learner to quickly and accurately find the right educational tools, and to implement this method in prototype of knowledge-based recommender system.

The objectives of the Doctoral thesis are as follows:

1. To investigate personalised e-learning technological peculiarities, i.e., recommender systems applications for learning personalisation, and those systems components.
2. To analyse existed selection methods for Web 2.0 tools suitable for implementing learning activities.
3. To propose the method to compose Web 2.0 tools for personalised learning process according to learners learning styles.

4. To develop a prototype of the recommender system that implements the method proposed.
5. To perform expert evaluation of the developed system prototype that implements the method proposed.

1.4. Research Methodology

The basis of the research methodology used in this work consists of analytic, generalising, constructive and evaluative methods.

1.5. Scientific Novelty

Most of the existing researches focus on e-learning systems personalisation functionalities such as personalised learning plans and learning material recommendations for learners. In practice and in many references, the need for the application of Web 2.0 tools in education is highlighted. There is a trend related with technology enhanced learning, focused on the personalisation of learning, which means that e-learning environments need to be more adapted to the learner and be open to the inclusion of a new set of Web 2.0 tools, which are under the student's control. But on the other hand, there is a risk that the learner's choice will not be right and the chosen tool would not enable a learner to achieve the learning objectives.

The main novel aspects of the method proposed in the Doctoral thesis are as follows:

1. The method proposed to recommend a suitable Web 2.0 tool for a particular learner is based on preferable types of learning activities and learning materials.
2. This recommendation is based on a comparison of the learner profile (that is based on the VARK learning style of the learner) and the description of learning content managing tools (i.e. Web 2.0 tools). The learner's profile and the Web 2.0 tools description are ontological data structures.

The proposed and implemented method supports learner to achieve the specified goals (i.e. to find suitable tools for personalised learning) quickly, accurately (i.e. the degree to which the product provides the correct results with the needed degree of precision) and completely (i.e. the degree to which a product meets all requirements) in a specified context of use.

1.6. Defended Propositions

1. The knowledge-based recommender system and the domain description in ontology are applicable to personalised learning, i.e. the most appropriate tools, for learner's desirable learning activity performance, can be selected based on his/her learning style.
2. The proposed method of Web 2.0 tools and learning process composition allows users to quickly and accurately select the proper tool suitable for learning activity performance.

1.7. Practical Importance

The main practical importance of the work is that the method proposed could be applied to learning personalisation and improvement in general, vocational, and higher education institutions.

The domain knowledge described using the OWL language could be used in different recommender systems by providing proposals to personalise learning taking into account not only the learning content but also learning activities.

The experimental approbation of the method proposed has shown that the method is applicable in the real-life education context, i.e. it is accurate, complete, and efficient in terms of time spent. Educational institutions using the method proposed could achieve better results in terms of learning personalisation, quality, and higher learners' motivation.

The description of Web 2.0 tools by means of ontology is suitable not only for knowledge-based recommender systems, but also for other types of recommender systems that use an item description for recommendations (e.g., content-based, community-based systems).

1.8. Publication and Approbation

The results of the Doctoral thesis were published in 6 scientific publications (5 of them in periodical peer-reviewed journals, and 1 – in the proceedings of other scientific conference).

The full list of publications on the topic of the Doctoral thesis is presented at the end of this Summary.

The results of the Doctoral thesis were presented via 15 presentations, given in international and national conferences and seminars as follows:

1. 4th International Conference 'Tech-Education' . Nice, France (August, 2013).
2. Seminar at University of Eastern Finland edTech-lab 'Research on Web 2.0 Technologies in Education'. Joensuu, Finland (May, 2013).
3. 3rd International Doctoral Consortium on Informatics and Informatics Engineering Education Research: Methodologies, Methods and Practice. Druskininkai, Lithuania (December, 2012).
4. 53rd Conference of Lithuanian Mathematicians (the conference was held by the Society of Lithuanian Mathematicians). Vilnius, Lithuania (June, 2012).
5. Seminar at 8th Joint European Summer School on Technology Enhanced Learning 'Research on Web 2.0 Technologies in Education'. Estoril, Portugal (May, 2012).
6. 2nd International Doctoral Consortium on Informatics and Informatics Engineering Education Research: Methodologies, Strategies and Implementation. Druskininkai, Lithuania (December, 2011).
7. 52nd Conference of Lithuanian Mathematicians (the conference was held by the Society of Lithuanian Mathematicians). Vilnius, Lithuania (June, 2011).
8. International Scientific Practical Conference 'Aspects of sustainable development: theory and practice'. Utena, Lithuania (April, 2011).

9. International Scientific Conference ‘Studies in Modern Society‘. Šiauliai, Lithuania (March, 2011).
10. Doctoral consortium on Informatics and Informatics Education. Druskininkai, Lithuania (December, 2010).
11. International Conference ‘Learning community and Web 2.0 technologies’. Vilnius, Lithuania (October, 2010).
12. 51st Conference of Lithuanian Mathematicians (the conference was held by the Society of Lithuanian Mathematicians). Vilnius, Lithuania (June, 2010).
13. Seminar at Teach@us Project meeting ‘NING and ELGG social platforms review’, ‘Web 2.0 technologies in Lithuanian schools, good practices examples ‘. Funchal, Madeira, Portugal (May, 2010).
14. Seminar at Vilnius University Institute of Mathematics and Informatics ‘Web 2.0 technologies. Introduction’. Vilnius, Lithuania (March, 2010).
15. Seminar at Vilnius University Institute of Mathematics and Informatics ‘Internet Use in Schools: Promise and Problems’. Vilnius, Lithuania (February, 2010).

1.9. Structure of the Doctoral Thesis

The Doctoral thesis consists of four chapters, general conclusions and results, references, and glossary. The work includes 146 pages of text, 25 figures, and 22 tables. The Doctoral thesis is written in Lithuanian.

The *first* (introductory) chapter includes the statement of the problem, its relevance, research aim and objectives, its scientific novelty and practical importance, as well as work’s approbation and publications.

The *second* chapter is analytical. It is aimed to present results on the main concepts and components of Web 2.0 tools, personal e-learning environments and recommender systems analysis and examples as well as the methods of applying Web 2.0 tools in the learning process.

The *third* chapter presents a method of recommending suitable Web 2.0 tools for a particular learner based on preferable types of learning activities and learning materials, and the developed prototype of recommender system which implements this method.

The *fourth* chapter is aimed to evaluate the quality of developed system prototype which has implemented the method proposed. It presents the results of the expert evaluation of the prototype created using Fuzzy numbers technique.

2. ANALYSIS OF WEB 2.0 TOOLS IN E-LEARNING

In this section, the results of the analytical part of the dissertation (Chapter 2) are briefly presented.

2.1 E-learning personalisation process

The E-learning environment is a computer-based online learning system. It supports learner by providing opportunities to learn at the time and location according to the learner's choice and allows his/her interactions with other learners, as well as ensures access to a wide range of learning resources and tools. The E-learning environment, that provides a set of personalisation functionalities, such as personalising learning plans, learning materials, and is capable of initializing the interaction with learners by providing suggestions to online learners, is called a personalised e-learning environment. One of the major challenges involved in developing personalised systems is to achieve effective personalisation functionalities, such as personalised content management, the learner's model, and adaptive instant interaction. Adaptive systems, autonomous intelligent agents and recommenders provide an important technology for accomplishing personalisation in e-learning systems. Adaptive and intelligent technologies can enhance different sides of learning.

Adaptive hypermedia systems (AHS) build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user (Brusilovsky, 1996). Systems that allow the user to change certain system parameters and adapt their behaviour accordingly are called adaptable. Systems that adapt to the users automatically based on the system's assumptions about user needs are called adaptive (Oppermann, 1994).

The goal of intelligent agents and recommenders is the use of knowledge about the domain, the learner, and the learning process to support personalised learning: to improve the learning activities.

Recommender systems (as a kind of services in the e-learning environment) can provide personalised learning recommendations to learners. Recommender systems are information processing systems that gather various kinds of data in order to create their recommendations. The data are primarily about the items (objects that are recommended) to be suggested and the users who will receive these recommendations (Ricci et al., 2011, p.7). The data can be formalized in a domain ontology (Chapter 2.1.1), thus the knowledge about a user and items becomes reusable for people and software agents (Li et al., 2007; Youn, Mcleod, 2006; Wang, Huang, 2013; Vesin et al., 2013; Vesin et al., 2012; Chen et al., 2012). Also, the ontology could contain a useful knowledge that can be used to infer more interests than can be seen by just an observation.

The suggestions relate to various decision-making processes.

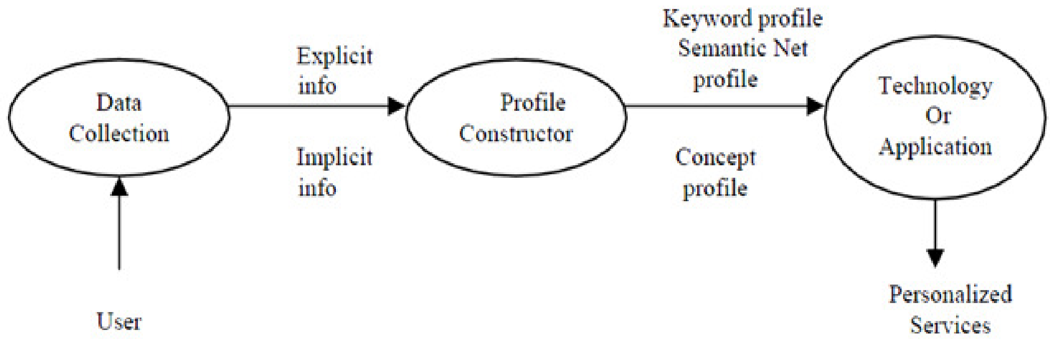

Fig. 1. Overview of user-profile-based personalisation (by Gauch et al., 2007)

As shown in Figure 1 (by Gauch et al., 2007), the user profiling process generally consists of three main phases:

1) Information collection – the process that is used to gather raw information about the user. Depending on the information collection process selected, different types of user data can be extracted.
2) User profile construction (from the user data). There is a variety of ways in which profiles may be represented and constructed.
3) Information in the user profile exploitation. It is done by technology or application in order to provide personalised services.

User profile construction is typically either knowledge-based or behaviour-based (Middleton et al., 2009). Knowledge-based approaches use static models of users and dynamically match users to the closest model and that of behaviour-based apply the user's behaviour as a model, commonly using machine-learning techniques. To obtain behaviour-based knowledge, behavioural logging is used, and knowledge-based approaches often use interviews and questionnaires for gathering knowledge.

In e-learning systems learner's profiles can be modelled (for personalisation purpose) by several techniques (Dagger et al., 2002):

1) Creating fixed stereotypes. Learners are categorized and the system customizes its performance based on the category that has been set for the learner.
2) Constructing learner's knowledge. A model of the learner's knowledge is constructed on the concept-by-concept basis and updated with the progress of the user through the system.
3) Combined techniques. The learners are categorized by stereotype initially and then this model is gradually modified, based on learner's interaction with the system.

User profiles can be represented as sets of weighted keywords, semantic networks, weighted concepts, or association rules (Gauch et al., 2007). Both the network-based and concept-based profiles are represented by conceptual nodes and relationships between those nodes. However, in the concept-based profiles, the nodes represent abstract topics considered interesting to the user, rather than specific words or sets of related words. The Keyword-based and concept-based profiles are often represented as vectors of weighted features. However, in the concept-based profiles, the features represent concepts rather than words (or sets of words).

As mentioned before, one of the features of contemporary e-learning is personalisation because learners should be treated as individuals with differences such us learning styles. The term 'learning style' refers to the concept that individuals differ with regard to which mode of instruction or study is most effective to them (Pashler et al., 2008). Various learning style models are developed. In the work of Coffield et al. (2004) there is a detailed analysis of the best known learning style models. In (Popescu, 2009) a summary of learning preferences, extracted from learning style models (by the main features), is presented. These preferences can be, for example, a specific manner of approaching a learning task, learning strategies activated in order to fulfil the task, preferable ways of gathering, organizing, or thinking about information.

One of the most popular learning style instrument is VARK inventory, designed by Fleming in 1987 (Moazeni, Pourmohammadi, 2013). VARK is an acronym made from *Visual*, *Aural*, *Read/write* and *Kinesthetic*. These modalities are used for preferable ways of learning (taking and giving out) information. Visual learners prefer to receive information from depictions in figures: in charts, graphs, maps, diagrams, flow charts, circles, hierarchies, and others. It does not include pictures, movies and animated websites that belong to Kinesthetic. The aural perceptual mode describes a preference for spoken or heart information. Aural learners learn best by discussing, oral feedback, email, chat, discussion boards, oral presentations. Read/write learners prefer information displayed as words: quotes, lists, texts, books, manuals. The kinaesthetic perceptual mode describes a preference for reality and concrete situations. They prefer videos, teaching others, pictures of real things, examples of principles, practical sessions, and others. *Multimodals* are those learners who have preferences in more than one mode (Fleming, 2006).

2.1.1 Ontology in recommender systems

Ontologies can support the definition of such components of recommender system (Buriano et al., 2006):

1) the context features and the candidate items
2) the output
3) the recommendation process and
4) functional modules.

Such information modelling can contribute to tailor the right information to a user and thus facilitate the user-system interaction.

The word 'ontology' was taken from Philosophy, where it means a systematic explanation of being. One of the first definitions was given by (Neches et al., 1991): 'an ontology defines the basic terms and relations comprising the vocabulary of a topic area as well as the rules for combining terms and relations to define extensions to the vocabulary'.

Since ontologies are widely used for different purposes (e.g. natural language processing, knowledge management, e-commerce, intelligent integration information, the semantic web, etc.) in different communities (i.e., knowledge engineering, databases and software engineering), (Uschold, Jasper, 1999) provided a new definition of the word 'ontology' to popularise it in other disciplines: 'An ontology may take a variety of forms, but it will necessarily include a vocabulary of terms and some specification of their meaning. This includes definitions and an indication of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretations of terms'.

According to (Mizoguchi, 2004), ontologies are used for various purposes: as a common vocabulary, data structure, explication of what is left implicit, semantic interoperability, explication of design rationale, systematisation of knowledge, a meta-model function, theory of content, etc.

A series of approaches has been reported for developing ontologies. In Corcho et al. 2003) an overview of the most known methodologies since 1990 is presented.

In the current study, we develop an ontology mainly based on the (Fernández et al., 1999) METHONTOLOGY method which proposes such activities: (1) the specification activity (states why the ontology is being built, what its intended uses are and who the end-users are), (2) the conceptualization activity (developing an ontology conceptual model), (3) the formalization activity (transformation of the conceptual model into a formal or semi-computable model), (5) the implementation activity (creating computable models in the ontology language), and (6) the maintenance activity (evaluation, corrections and updates). During the specification activity, Uschold, and King (1995) propose three strategies for identifying the main concepts in the ontology: a top-down approach, where the main abstract concepts are identified and then specialised into more specific concepts; a bottom-up approach, in which the most specific concepts are identified and then generalised into more abstract concepts; and a middle-out approach, in which the most important concepts are identified and then generalised and specialised into other concepts and Gruninger, and Fox (1995) suggest to identify a set of competency questions that must be answered by a model built based on the ontology. The ontology must be able to provide a vocabulary for expressing these questions. Axioms in the ontology should be able to characterize the answers to the competency questions.

Sure et al. (2003, p.7) proposed three different types of evaluation: (1) technology-focussed evaluation, (2) user-focussed evaluation, and (3) ontology-focused evaluation. The technology-focussed evaluation consists of two main aspects: (1) evaluation of the properties ((e.g., language conformity (Syntax), consistency (Semantics)) of ontologies generated by development tools, (2) evaluation of the technology properties (interoperability, turn around ability, scalability, etc.).

The Web Ontology Language (OWL) is a language developed by W3C and is an extension of RDF Schema and also employs the triple model.

OWL takes the basic fact-stating ability of RDF and the class- and property-structuring capabilities of RDF Schema and extends them. In OWL (Horrocks et al., 2003):

1) classes can be declared and organised in a subsumption ('subclass') hierarchy;
2) classes can be specified as logical combinations (intersections, unions, complements) of other classes, or as enumerations of specified objects;
3) properties can be declared and organized into a 'subproperty' hierarchy, domains (OWL classes) and ranges (OWL classes or externally-defined data types such as string or integer) can be provided for these properties;

4) properties can be stated as transitive, symmetric, functional, or inverse of another property;
5) it can be expressed which objects (individuals) belong to which classes, and what the property values are of specific individuals;
6) equivalence statements can be made on classes and on properties;
7) disjointness statements can be made on classes;
8) equality and inequality can be asserted between individuals;
9) restrictions can be provided on how properties behave that are local to a class;
10) classes can be defined where a particular property is restricted so that all the values for the property in individuals of the class should belong to a certain class (or data type) and
11) at least one value must be from a certain class (or data type), and there must be at least certain specific values, and there must be at least or at most a certain number of distinct values.

OWL is a syntactic variant of the $\mathcal{SHOIN}(\mathrm{D})$ description logic (DL), offering a high level of expressiveness while still being decidable (Motik et al., 2005). OWL DL (one of the three species of OWL) can be viewed as expressive Description Logics, with an ontology being equivalent to a Description Logic knowledge base (Horrocks et al., 2003).

OWL classes are interpreted as sets that contain individuals. They are described using formal (mathematical) descriptions that state precisely the requirements to a membership of the class. Properties are binary relations on individuals, i.e. properties link two individuals together, e.g. the property *hasFunction* might link the individual from the class *Tool* to the individual from the class *ToolFunction*. Properties can have inverses, e.g., the inverse of *hasFunction* is *isFunctionOf*.

Description Logics (DLs) is a family of class-based (concept-based) knowledge representation formalisms that represent the knowledge of an application domain by first defining the relevant concepts of the domain (its terminology), and then using these concepts to specify the properties of objects and individuals occurring in the domain (Baader, Nutt, 2003; Horrocks et al., 2003). Figure 2 sketches the architecture of a knowledge representation system by Baader, and Nutt (2003).

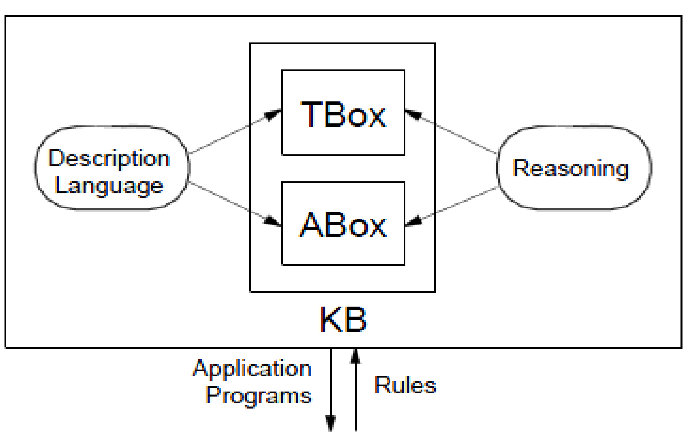

Fig.2. Architecture of a knowledge representation system based on Description Logics by Baader, and Nutt (2003)

A knowledge base (KB) comprises two components (Baader et al., 2008):

(1) *terminological part* (called the TBox) that introduces the terminology - the vocabulary (concepts which denote the sets of individuals, and roles, which denote binary relationships between individuals) of an application domain. The TBox can be used to assign names to complex descriptions;

(2) *assertional part* (called the ABox) that contains assertions about the named individuals in terms of this vocabulary.

The language $\mathcal{AL}$ (attributive language) has been introduced in (Schmidt-Schauß and Smolka, 1991) as a minimal language that is of practical interest. The other languages of this family are extensions of $\mathcal{AL}$. For example, the DL that includes conjunction, disjunction, negation, existential restriction and value restriction, is called $\mathcal{ALC}$. $\mathcal{ALC}$, extended with (qualified) number restrictions, inverse roles, transitive roles, subroles, concrete domains, and nominals, is called $\mathcal{SHOIN}(\mathbf{D})$.

DL usually reflects its expressive power, with the letters expressing the constructors provided. The expressive DL which corresponds to the OWL DL is briefly described below (Baader et al., 2008):

1) letter $\mathcal{S}$ is often used as an abbreviation for the 'basic' DL consisting of $\mathcal{ALC}$ extended with transitive roles,
2) letter $\mathcal{H}$ represents subroles (role $\mathcal{H}$ierarchies),
3) letter $\mathcal{O}$ represents nominals (n$\mathcal{O}$minals) - if a is an individual name, then $\{a\}$ is a concept, called a nominal;
4) letter $\mathcal{I}$ represents inverse roles ($\mathcal{I}$nverse),
5) letter $\mathcal{N}$ represents number restrictions ($\mathcal{N}$umber) – it describes the number of relationships of a particular type in which individuals can participate.

The integration of a concrete domain/datatype is indicated by appending its name in parenthesis, but sometimes 'generic' **D** is used to express that some concrete domain/datatype has been integrated.

There is a variety of reasoning techniques for DL reasoning problem solving (for example, resolution-based approaches, automata-based approaches, structural approaches), however, the most widely used technique is the tableau-based approach first introduced by Schmidt-Schauß and Smolka (Schmidt-Schauß, Smolka, 1991). The idea behind the algorithm is that it tries to prove the consistency of a knowledge base (KB) by constructing (a representation of) a model of KB. The tableau-based decision procedure for the consistency of KB is described in more detail in (Baader et al., 1990). This algorithm is implemented in some reasoners' systems, for example, *FaCT++*,

RACER Pro, *Pellet* (Sirin et al., 2007). An OWL consistency checker takes a document as input, and returns one word being Consistent, Inconsistent, or Unknown. The OWL Pellet reasoner provides such main DL inference services (Sirin et al., 2007):

1) *Consistency checking* ensures that an ontology does not contain any contradictory facts. It means the operation to check the consistency of an ABox with respect to a TBox;
2) *Concept satisfiability* checks whether it is possible for a class to have any instances. If a class is unsatisfiable, then defining an instance of the class will cause the whole ontology to be inconsistent;

3) *Classification* computes the subclass relations between every named class to create complete class hierarchy. The class hierarchy can be used to answer queries such as getting all or only direct subclasses of a class;
4) *Realization* finds the most specific classes that an individual belongs to - computes the direct types for each of the individuals. Realization can only be performed after a classification since direct types are defined with respect to a class hierarchy. Using the classification hierarchy, it is also possible to get all the types for that individual.

Also it should be noted that OWL has the following features (Horrocks et al., 2003):

1) *open world assumption*: a statement cannot be assumed true on the basis of a failure to prove it;
2) *unique names assumption*: if two individuals (or classes, or properties) have different names, we may still derive by inference that they must be the same.

In recent years, researchers have developed a lot of tools for developing the ontology, e.g., *Protégé*, *SWOOP*, *Top Braid composer*, *OilED*, *WebODE*, *Ontolingua*, *Internet Business Logic*, *OntoTrack*, *and IHMC Cmap Ontology Editor* (Khondoker, Mueller , 2010; Cardoso, Nunes Escorcio, 2007). By a systematic review, the most popular tools were selected and evaluated according to the extracted criteria proposed by (Cardoso, Nunes Escorcio 2007; Kapoor, 2010; Khondoker, Mueller, 2010; Duineveld, 2000; Lambrix , 2003; Mizoguchi, 2004; Su, Ilebrekke, 2002). Therefore, Protégé 4.3 tool was selected for our domain ontology development. It meets the following requirements:

1) tool is free,
2) it supports OWL,
3) it has 'user friendly' interface,
4) it has 'help' tutorial,
5) it checks ontology consistency,
6) it can execute queries.

2.2. Recommender systems in TEL

The aim of technology enhanced learning (TEL) is to improve learning.

It is therefore an application domain that generally covers technologies that support all forms of learning activities (Manouselis et al., 2011). An important activity in TEL is search-ability relevant learning resources and services as well as their better finding. Recommender systems support such an information retrieval.

Recommender systems offer suggestions for items that may be useful to a user applying different task implementation types, such us *Find Some Good Items*, *Find all good items*, *Recommend a sequence*, *Just browsing,* and so on (Ricci et al., 2011, p.7). Most of these tasks are valid in the case of the TEL recommender systems as well (Manouselis et al., 2011). For example, a recommender system supporting learners to achieve a specific learning goal, 'providing annotation in the context' or 'recommending a sequence' of learning resources are relevant tasks.

There are different types of recommender systems, based on the recommendation approaches (Ricci et al., 2011, p.11):

1) *Content-based*: The system learns to recommend items similar to the items that the user liked in the past. The similarity of items is calculated based on the features associated with the compared items.
2) *Collaborative filtering*: The system recommends to the user the items that other users with similar tastes liked in the past. The similarity is calculated based on the similarity in the rating history of the users.
3) *Demographic*: The system recommends items based on the demographic profile of the user based on different demographic niches.
4) *Knowledge-based*: Knowledge-based systems recommend items based on the specific domain knowledge about how certain item features satisfy users' needs and preferences as well as how the item is useful for the user. Knowledge-based recommender systems can be rule-based or case-based.
5) *Community -based*: The system recommends items based on the social relations of the users and preferences of the users' friends, i.e. on ratings that were provided by the user's friends.
6) *Utility-based*: The system recommends items based on the calculation of the utility of each item according with the user interests preferences (Martinez et al., 2008).
7) *Hybrid*: The system combine different techniques of different recommender systems in order to avoid the drawbacks that other systems face in some situations.
8) *Semantic*: The system incorporates semantic knowledge in its processes, so the recommendation quality is improved. The items and the user profile representation are based on the ontology (Codina, Ceccaroni, 2010a; Codina, Ceccaroni, 2010b; Middleton et al., 2009).

Knowledge-based recommender systems described in detail below.

Information filtering systems that recommend items to users according to their preference and the characteristics of the required item, represent the knowledge of experts, and manipulate the expertise to solve problems at an expert's level of performance, are called knowledge-based recommendation systems (Husain, Dih, 2012; Jadhav, Sonar, 2009). The fundamental reasoning methods in such systems are rule-based and case-based. The form of data collected by the knowledge-based system about user's preferences can be statements, rules, or ontologies.

Rule-based reasoning is deductive which mimics the problem solving behaviour of the human experts. The knowledge base of the rule-based system comprises the knowledge that is specific to the domain of the application. Case-based reasoning is inductive which solves problems by adapting the solution of more similar cases solved in the past. A new problem is matched against the cases in the case-base and one or more similar cases are retrieved (Jadhav, Sonar, 2009).

The Rule-based reasoning system represents knowledge of the system in terms of a bunch of rules (facts) (Kapoor et al., 2010). These rules are in the form of IF THEN rules such as "IF some condition THEN some action". If the 'condition' is satisfied, the rule will take the 'action'.

2.3. Research on Web 2.0 tools for learning

The original World Wide Web (www) invented by Tim Berners-Lee and known as Web 1.0 was a read-only medium, while Web 2.0 is a read/write medium. It means that

Web 1.0 users had to be familiar with the HTML language in order to create any content in www, whereas the users of Web 2.0 need to have only the basic computer technology skills.

The term Web 2.0 is characterized as the application of tools that enable particular interactive capabilities: coproduction, social networking, and unprecedented forms of communication, with user control and syndication of the Web content (Conger, 2009). For example, communications on wikis, e-book reviews, sharing of the content on *MySpace*, island development in *SecondLife* and syndications via *Youtube* , blogging platforms, and RSS.

Web 2.0 tools can be defined as web applications that facilitate participators' information sharing, interoperability, user-centered design, and collaboration on the World Wide Web (Kolesinski et al., 2013, p.16).

Tim O'Reilly (O'Reilly, 2006) indicated four levels of Web 2.0 tools :

Level 3: The application that could only exist on the net and draws its essential power from the network and the connections it makes possible between people or applications. For example, *EBay*, *craigslist*, *Wikipedia*, *del.icio.us*, *Skype*. They are fundamentally driven by a shared online activity.

Level 2: The application that could exist offline, but it is uniquely advantaged by being online. For example, *Flickr* where there is an ability to have a local photo management application, however the shared photo database, the online community, and the artefacts it creates (like the tag database) are basic to what distinguishes *Flickr* from its offline counterparts.

Level 1: The application that can and does exist offline, but it gains additional features by being online. For example, *Writely* which enable both to do collaborative editing as well as to write alone.

Level 0: The application that has been primarily taken hold online, but it would work just as well offline if you had all the data in a local cache. For example, *MapQuest*, *Yahoo! Local* and *Google Maps.*

Web 2.0 tools advantages influence these tools to be used in learning, especially in e-learning. Thus the term E-learning 2.0 has emerged, which defines the new form of e-learning that includes Web 2.0 technologies and allows learners to use Web 2.0 technologies, to take an active role in the learning process, and determine their own learning strategies according to their interests and needs (Czerkawski, 2011, p. 9). Web 2.0 tools and their applications in education are briefly presented in (Bower et al, 2010; Conole, Alevizou, 2010).

E-learning 2.0 differs from traditional e-learning because it enables learners not only to receive, read, or respond to the learning content, but also to create the content and to collaborate with peers, thus forming a learning network with distribution of content creation and responsibilities, with an easy access to the content through search, aggregation, and tagging. Thus, the learners have opportunities to interact with peers and the learning content, share thoughts, and write comments (Yuen, 2010).

However, Web 2.0 tools, used in learning, do not mean an improvement of the learning process. In literature the need for deeper conceptualisation of the relationship between Web 2.0 tools and learning processes, clarification of how and by what means these tools support learning is highlighted (Kuswara, Richards, 2011; Bower et al., 2010).

Research on the relationship between Web 2.0 tools and the learning process is often focused on the enrichment of learning activities provided by these tools (Conole, Fill, 2005; Starkey, 2011; Khalid et al., 2012). The action, that a learner can potentially perform in learning environment by using a particular tool, is called an affordance (John, Sutherland, 2005; Lee, McLoughlin, 2008). For example, social tools affordances are sharing, communication and information discovery.

In (Lee, McLoughlin, 2008) the authors indicated the following affordances:

1) *Connectivity and social rapport*. It occur in spaces (for example, Social networking sites) where people acquire social and communicative skills, creativity, expressive forms of behaviour and identity seeking.
2) *Collaborative information discovery and sharing*. It occur in software applications (for example, blogging service, bookmarking service) where the data can be shared.
3) *Content creation*. Occur in software applications (for example, wiki) where the content can be created.
4) *Knowledge and information aggregation and content modification*. It occur in software applications (for example, Simple Syndication (RSS), vodcasting services) which involve the syndication (collection of material from many sources) and aggregation of the content.

Bower (Bower, 2008) described categories of affordances defined as abilities (the action possibilities they offer to the user) which can be applied in combination to meet the learning objectives for different types of tasks, for example, *media* affordances category that is divided into subcategories, based on the type of input and output forms: text (‘read-ability’, ‘write-ability’), images (‘view-ability’, ‘draw-ability’), audio (‘listen-ability’, ‘speak-ability’), and video (‘watch-ability’, ‘video-produce-ability’).

The works that deal with educational aspects of learning tools, to be precise, mapping tools and pedagogy are presented below.

Conole and Fill (2005) presented a framework and learning design toolkit which guides users through the process of creating pedagogically informed learning activities by using appropriate tools and resources. The authors defined the learning activity as an action which occurs within a context with a set of associated attributes and addresses a set of learning outcomes. These outcomes can be achieved through a sequence of tasks and associated roles adopted by the learners which might call upon a set of tools and resources. The toolkit developed offers appropriate media, based on the media category (one of five based on (Laurillard, 2002, p.90): Narrative, Communicative, Adaptive, Productive, and Interactive), the desired learning outcomes (e.g. understand, demonstrate, design, produce, appraise) and strategies (tasks).

The performance of the approach of Web 2.0-enabled learning design is described by Bower (2010). According to the author for the proper tool selection we need to consider the following four element groups of the learning design:

1) The overarching learning goals and objectives (outcomes).
2) The type of content in terms of knowledge to be represented and cognitive processes in which students are expected to engage.

3) The type of pedagogy to be applied (transmissive, dialogic, constructive, co-constructive)
4) The preferred modalities of representation (text, image, audio, and/or video), the type of collaboration, and the level of synchronicity required.

Then, based on these elements, matched to the Web 2.0 tools potential to satisfy these requirements, suitable Web 2.0 tools, can be selected.

The digital age learning matrix, presented by Starkey (Starkey, 2011) is a framework for combining digital tools use (accessing information, presenting, processing information, gaming or interactive programs) with the aspects of learning (doing, thinking about connections, thinking about concepts, criticising and evaluating, creating knowledge, sharing knowledge).

Another framework of tools mapping (both online and offline) with the problem-and-project-based learning activities, that include the tasks (e.g. brainstorming, argumentation, literature storing) performed by learner to achieve learning outcomes in a learning environment while interacting with people or resources, is presented in (Khalid et al., 2012).

Vega-Gorgojo et al. (2008) present a framework of a suitable (for learning task accomplishment) tool selection. It maps a particular tool with a desirable task to perform. The authors state that the tool supports one or more learning tasks (person-based, group-based or computer-system-based) performed by an actor (person, group or computer system) who can play some role (e.g. editor, communicator, publisher). Tasks are divided into five types: Perception, Construction, Communication, Computation and Information Management. The realization of these tasks may require an artefact (e.g. document, vote) as input or may produce an artefact (e.g. message, calendar) as output.

Targamadzė and Petrauskienė (2012) proposed a framework of IT (information technology, e.g. email, forum board) tool selection for accomplishing particular course educational activities, based on learning aims, methods, and content.

3. THE METHOD OF COMPOSING THE WEB 2.0 TOOLS AND THE LEARNING PROCESS

Generalizing the results of the previous chapters, we can state that when planning the learning process first of all we have to set the learning objective (or outcome) (Conole, Fill, 2005; Bower et al, 2010; Targamadzė, Petrauskienė, 2012). One of the basic and essential elements within the education community is a classification of learning objectives (especially, cognitive) in the education, presented by Bloom (1956) is Bloom's taxonomy. The learning objectives can be achieved through a sequence of tasks, performed by the learner. These tasks form a learning method.

The Learning 2.0 allows learners to use Web 2.0 tools, to take an active role in the learning process, and to determine their own learning strategies according to their interests and needs. Active learning methods and Web 2.0 tools can enhance the learning effectiveness, however, it is important to consider each learner's individual preferences. Personalisation deals with this kind of problem. This work takes into account the learner's preferences to the educational material (based on VARK learning styles model) and communication modes. The proposed Web 2.0 tools and the learning process composition method were implemented in prototype of the system. This prototype has been developed following the working principles of the knowledge-based recommender system. The domain knowledge was conceptualized in the ontology. Chapter 3.1 presents the basic elements of developed ontology. The proposed method is introduced in Chapter 3.2.

3.1. Description of the basic elements of the proposed composition method of Web 2.0 tools and learning process

With the view to find a particular Web 2.0 tool suitable for learner (for learning activity accomplishment), a link between the tool and the learning activity must be identified. This relationship can be established by interconnections between the defined tool and activity elements.

The <u>Learning activity</u> is defined as consisting of the following elements:

1) *Learning Activity* (what action a learner performs)
2) *Content* (which object a learner manages)
3) *Interaction* (with whom a learner interacts)
4) *Synchronicity* (at what time a learner performs the intended action).

<u>Web 2.0 tool</u> is defined as set of universal functions. This universal function is defined as consisting of the following elements:

1) *Function* (what action can be performed by using a tool)
2) *Artefact* (which object can be managed by using a tool)
3) *Interaction* (what kind of interaction the tool enables)
4) *Synchronicity* (at what time the intended action is enabled by a tool to take place).

The Learning activities and Functions of tools are classified mostly based on the Conole and Fill (2005) media taxonomy. These types and particular elements are presented in Table 1.

Table 1. Learning activities and Web 2.0 tools functions types

Type	*Learning activities*	*Subtype (1 -8)*	*Web 2.0 tool function*
Narrative	*Revise*	*1 - View*	*Explore (Read, view, listen)*
Information management	*Find*	*2 - Search*	*Search*
	Collect	*3 - Host*	*Store, Syndicate*
Productive	*Prepare*	*4 – Create*	*Create (draw, write, record, edit)*
Communicative	*Present*	*5 – Share*	*Share, Publicise*
	Dispute	*6 – Discuss*	*Communicate*
Imitative	*Role play*	*7 - Imitate*	*Simulate (Game simulation)*
	Observation	*8- Model*	*Model (Phenomenon modelling)*

Thus, Web 2.0 tools could be divided based on their usage possibilities, managed objects, communication form, and sort of imitation process into three groups as follows:

1) Artefacts management,
2) Communication, and
3) Imitation tools.

We have defined the following components in the domain ontology visualised with Protégé 4.3 ontology editor:

1) Concepts (Main Classes) (Figure 3), and
2) Relationships between Concepts (Properties) (Figure 4):

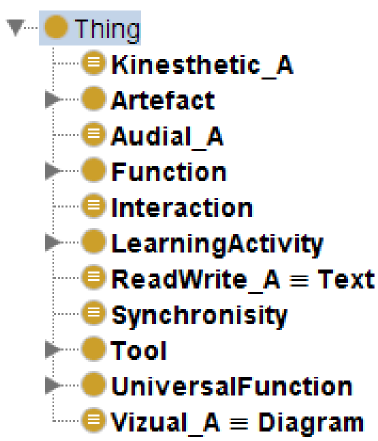

Fig 3. The main ontology classes

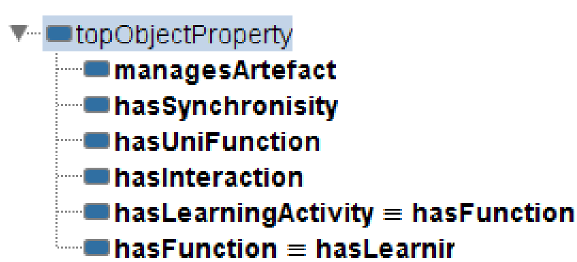

Fig 4. Ontology properties

Domain and range of properties are presented in Table 2.

Table 2. Domain and Range of properties

Property	**Domain**	**Range**
hasUniFunction	*Tool*	*UniversalFunction*
hasFunction≡hasLearningActivity	*UniversalFunction*	*Function*
managesArtefact	*UniversalFunction*	*Artefact*
hasInteraction	*UniversalFunction*	*Interaction*
hasSynchronisity	*UniversalFunction*	*Synchronisity*

3.2. The steps of composition method of Web 2.0 tools and learning process

These steps are as follows:

1. Identification of learner's learning style (i.e. preferences of the learning content and communication modes).
2. Selection of the learning objective and the learning method.
3. Determination of the elements of chosen learning method activities.
4. Determination of universal function elements of each Web 2.0 tool.
5. Finding of the link between tool and learning activity elements.
6. Selection of a suitable tool based on specified elements: *Action*, *Interaction*, *Synchronicity*. *Artefact* is determined based on individual learning style.

Each step in detail is described below.

An official VARK learning styles model questionnaire[1] was used to diagnose particular learner's preferences. The users can select none or more than one answer to each question, relying on individual perception. Thus, as a result the preferences of learning content format are found.

When a learner is planning the learning process, first (s)he sets the learning objective. The learning method can be selected to achieve this objective (based on Lepečkienė, 1998). The learning method can be seen as a set of learning activities. Each learning activity can consist of four elements as described in Sub-section 3.1. Each Web 2.0 tool is analysed as a tool consisting of universal functions. Tool class is described by using closure axiom (i.e., universal restriction that acts along the property to say that it can only be filled by the specified fillers) due to Open World Assumption in OWL. These universal functions can consist of four elements as described in Sub-section 3.1.

Interconnections between the tool and learning activity elements are settled as follows:

- *LearningActivity* and *Function*
- *Content* and *Artefact*
- *Interaction* and *Interaction*
- *Synchronicity* and *Synchronicity*

With the view to select a suitable Web 2.0 tool, based on specified elements, the developed ontology was used. Queries could be performed only using a classified ontology. The OWL consistency checker *Pellet* was used for this purpose as well as for ontology *Consistency checking*, *Concept satisfiability*, and *Realisation*. Also, the DL QUERY tab of the *Protégé* ontology editor was used to answer the competency questions. The query language (class expression), supported by this plug-in, is based on the Manchester OWL syntax, a user-friendly syntax for OWL DL (Chapter 2.1.1) that is fundamentally based on collecting all the information about a particular class, property, or individual into a single construct, called a frame. The example of a formalized competency question "What tool is suitable for a visual learner individually to view the learning content?" in *Protégé 4.3* ontology editor is presented in Figure 5.

[1] http://www.vark-learn.com/english/page.asp?p=questionnaire

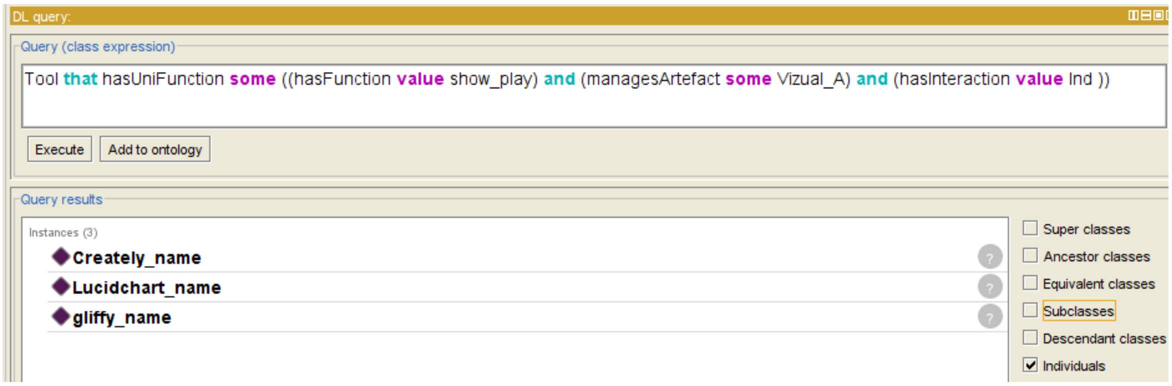

Fig. 5. The example of query

This query in the SHOIN(D) descriptive language is described as follows:

Tool ⊓ ∃hasUniFunction.(hasFunction.{show_play}⊓ ∃managesArtefact.Vizual_A ⊓ hasInteraction.{Ind})) = {Lucidchart, Creately, Gliffy}

Furthermore, this query could be written as follows：

Tool ⊓ ∃hasUniFunction.(hasLearningActivity.{view}⊓ ∃managesArtefact.Vizual_A ⊓ hasInteraction.{Ind})) = {Lucidchart, Creately, Gliffy}

Such a variety of question expressions is possible due to the statements equivalence made on the properties (e.g. hasFunction ≡ hasLearningActivity) and an equality asserted between individuals (e.g. {show_palay} ≡ {view}) in the developed ontology.

3.3 Prototype of the recommender system that implements the proposed method

The developed prototype of the knowledge-based recommender system (Fig. 6) implements the method proposed completely.

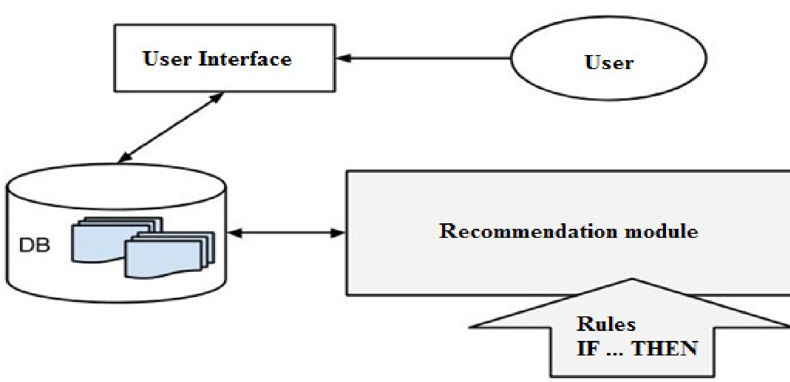

Fig. 6. Scheme of the recommender system

The system uses the background data before the recommendation process begins. These data are in the learner's profile (in **DB**). The profile has been modelled by creating fixed stereotypes. Thus, the learners (**USERS**) were attached to a particular category, based on the VARK learning styles model.

Also, the user's profiles were represented as sets of weighted keywords. Each keyword refers to the learning style (visual, aural, read/write, kinaesthetic), and the weights (numerical representations) indicate its importance in the profile.

The information needed for the system as input data (trough **USER INTERFACE**) was provided by a user by selecting the learning objective and the learning method as well as by specifying learning activities, i.e., desirable synchronicity and interaction.

The background and input data were combined and processed by programs (in the **RECOMMENDATION MODULE**) based on the IF…THEN rules. **If** all the interconnections between the tool and learning activity elements have been found **then** the appropriate tool (which has the specified properties) was recommended.

4. EXPERTS' EVALUATION OF THE QUALITY OF THE DEVELOPED SYSTEM PROTOTYPE IMPLEMENING THE PROPOSED METHOD

The method, proposed in the previous section, is aimed to support the learner to achieve the set goals (i.e., to find a suitable Web 2.0 tool for personalised learning) quickly, accurately and completely.

With s view to evaluate the quality of this method, it was implemented in the prototype of the recommender system. An expert opinion poll was conducted to evaluate it.

According to (Oppermann, Reiterer, 1997) expert evaluation methods draw upon expert knowledge to make judgements about the usability of the product for specific end-users and tasks. The expert may be that of a human factors as well as a designer with some basic knowledge of human factors.

In order to reduce the subjectivity of evaluation due to the expert's personal assessment a detailed presentation and instructions were used to evaluate the quality of the method proposed.

Since the expert evaluation method depends on the skill of the expert, the following competence requirements for their selection were defined:

1) no less than 10 year-experience in the field of education and ICT use for education in practice;
2) at least 3 scientific papers published in the field of informatics or informatics engineering;
3) doctor's degree in informatics or informatics engineering.

Also, a questionnaire, consisting of three questions, based on the ISO/IEC 25010 quality in use model, was prepared for evaluation.

The quality of a system is the degree to which the system satisfies the stated and implied needs of its various stakeholders, and thus provides value.

The quality in use is the user's view of the quality of a system, and is measured in terms of the result of using the system (i.e. how people behave and whether they are successful in their tasks), rather than the properties of the system itself. The output can be measured as effectiveness, productivity, and satisfaction of the users (ISO/IEC 25010).

The quality in use model is composed of five characteristics, which are further subdivided into sub-characteristics that can be measured when a product is used in a realistic context of use. In this work, three criteria were formulated to evaluate the system quality, i.e. (1) accuracy, (2) completeness, and (3) efficiency. The experts used linguistic variables ‘bad’, ‘poor’, ‘fair’, ‘good’, and ‘excellent’ to establish ratings (values) of the quality criteria. According to (Kurilovas et al., 2014), linguistic variables were converted into average triangle fuzzy numbers as follows: ‘excellent’=0.850; ‘good‘=0.675; ‘fair’=0.500; ‘poor’=0.325; and ‘bad’=0.150 In this work, three criteria were formulated to evaluate the quality (accuracy, completeness, and efficiency). Table 3 presents the questions and the corresponding options: ‘bad’, ‘poor’, ‘fair’, ‘good’ and ‘excellent’.

According to (Kurilovas, Serikovienė, 2013) fuzzy numbers and scalarisation methods are applicable to evaluate the quality. Other than in that work, triangular fuzzy numbers are used in the Doctoral thesis.

The scalarisation method can be seen as the experts’ additive utility function (a possible decision transforms a multi-criteria task into one criterion task obtained by adding all the criteria ratings (values) together with their weights), represented by the formula:

$$f(x) = \sum_{i=1}^{m} a_i f_i(x), \quad \sum_{i=1}^{n} a_i = 1, \ a_i > 1.$$

Here $f_i(x)$ is the rating (i.e. non-fuzzy value) of the criterion i, and a_i are the weights of the quality criteria.

Table 3. Questions of developed questionnaire

1. **Accuracy** of the achieved goals.	
EXCELLENT	86 -100 % accurate
GOOD	67 - 85 % accurate
FAIR	50 - 66 % accurate
POOR	33 - 49 % accurate
BAD	0 - 32 % accurate
2. **Completeness** of the achieved goals.	
EXCELLENT	86 -100 % complete
GOOD	67 - 85 % complete
FAIR	50 - 66 % complete
POOR	33 - 49 % complete
BAD	0 - 32 % complete
3. The **time** spent to achieve the goals compared with the time spent to achieve goals without the prototype.	
EXCELLENT	0 - 32 % more time spent
GOOD	33 - 49 % more time spent
FAIR	50 - 66 % more time spent
POOR	67 - 85 % more time spent
BAD	86 -100 % more time spent
Please comment all the options (except the optional "Excellent").	

The weights of quality criteria have been selected by the experts. To this end, normalised weights have been calculated, based on (Uppuluri, 1989). If there are r experts, and the importance (weight) of each criterion's is calculated as the average of the values selected by experts (m_f^i), then the weights are normalised according to the formula below:

$$a_i = \frac{m_f^i}{\sum_{s=1}^{r} m_f^s}, \text{ thus } \sum_{i=1}^{n} a_i = 1.$$

Experts' opinions on the criteria ratings are presented in Table 4.

Table 4. Experts' opinions on the criteria ratings and their average

Experts / Criteria	I	II	III	Average $f_{i(}x)$
Accurateness	0,850	0,850	0,850	0,850
Completeness	0,850	0,850	0,850	0,850
Efficiency	0,625	0,625	0,850	0,7

The weights and their averages selected by the experts are presented in Table 5.

Table 5. Criteria weights selected by experts

Experts / Criteria	I	II	III	Average m_f^i
Accurateness	0,850	0,850	0,850	0,850
Completeness	0,850	0,850	0,850	0,850
Efficiency	0,650	0,500	0,500	0,542
In total:				2,242

The normalised weights are presented in table 6.

Table 6. Normalised criteria weights

Criteria	Normalised criteria weights (a_i)
Accurateness	0,38
Completeness	0,38
Efficiency	0,24
	In total: 1,00

The experts' additive utility function is as follows:

$f(x) = 0{,}38 \times 0{,}85 + 0{,}38 \times 0{,}85 + 0{,}24 \times 0{,}7 = 0{,}323 + 0{,}323 + 0{,}168 = 0{,}814.$

It means that the system's quality reaches 81,4% of the quality level in comparison with that of 'ideal' (100%). So, the evaluated system is of good quality (68–85 %. – 'good').

GENERAL CONCLUSIONS AND RESULTS

1. In the research presented, while analysing Web.2.0 tools, and recommender systems, the following conclusions and results have been obtained:
   1.1. other than in scientific literature, in this work, the Web 2.0 classification method that helps a user to learn effectively in the Web 2.0 tools-rich environment has been proposed. With regard to the usage possibilities and managed objects, Web 2.0 tool could be divided into three groups as follows: (1) artefacts management tools, (2) communication tools, and (3) imitation tools. In this way it is possible to group Web 2.0 tools according to their usage possibilities and managed objects, their communication form and sort of imitation process.
   1.2. other than in scientific literature, in this work, it is proposed to personalise learning according to learner's preferences in terms of learning content and communication modes according VARK learning styles model theory.
   1.3. recommender systems are suitable to personalise learning by proposing the learning tools according to the learner's preferences. Knowledge-based recommender systems propose the elements associating their features with user's features described in the user profile that could be created in the e-learning system according to the learning styles theory. The domain knowledge and user profile used for recommending could be described by ontology, thus enabling knowledge reusability suitable both for human beings and program modules.
2. The method was proposed to compose Web 2.0 tools in the learning process, based on the research and analysis of their application in the learning process, and on recommender systems application to personalise learning as well as the practical experience gained using these tools:
   2.1. the method helps a learner to choose Web 2.0 tools suitable to implement a desirable learning activity according to his/her learning style, i.e. learner's preferences in terms of the learning content and collaboration form. Thus, the learning process is personalised.
   2.2. the elements of this method are described by the ontology in a formal way, which enables us to use domain knowledge and implement the method proposed in the recommender system.
3. While performing the expert evaluation of the system prototype, based on this method, it has been determined that:
   3.1. the results provided by the system are accurate – recommended tools are suitable to implement desirable learning activities, i.e. the tools proposed provide a possibility to perform a desirable pedagogical activity in time and to participate in it for a desirable number of learners, and artefacts managed by the tools are suitable for a particular learner according to his/her learning style.
   3.2. the system performance is complete and suitable, i.e. it fully corresponds to the method proposed and it operates as it was planned – the system recommends tools in a personalised way.
   3.3. using the created recommended system, it is possible to find Web 2.0 tools suitable for personalising learning quicker than without the system.

3.4. the method and prototype proposed are qualitative with regard to accurateness, completeness and efficiency criteria – the system is 81.4% of the absolute quality.

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LIST OF PUBLICATIONS BY THE AUTHOR ON THE SUBJECT OF DISSERTATION

The results of the Doctoral thesis were published in 6 scientific publications (5 of them in periodical peer-reviewed journals, and 1 – in the proceedings of other scientific conference).

Articles in peer-reviewed periodical journals:

1. Juškevičienė, A. (2010). Web 2.0 tools and education (Antrosios kartos saityno technologijos ir švietimas). *Lietuvos matematikos rinkinys. Lietuvos matematikų draugijos darbai*, 51: 103-108.
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Articles, published in other proceedings of scientific conferences:

1. Dagienė, V., Juškevičienė, A. (2010).Te@ch.us projektas - pasitelkime Web 2.0 technologijas mokymui ir mokymuisi. Mokymosi bendruomenė ir antrosios kartos saityno (Web 2.0) technologijos. Tarptautinės konferencijos pranešimai. Vilnius : Matematikos ir informatikos institutas: 40-46.

SHORT DESCRIPTION ABOUT THE AUTHOR

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SANTRAUKA

1.1. Darbo aktualumas

Terminas technologijomis grįstas (praturtintas) mokymasis panaudotas tada, kai atsirado asmeniniai kompiuteriai, t. y. kai kompiuteriai išplito ir tapo prieinami mokymo įstaigose bei namuose (apie 1970 metus). Dar didesnę įtaką mokymo ir mokymosi procesui padarė interneto atsiradimas ir išplitimas. Pradėtos kurti modernios internetinės technologijos, vadinamosios antrosios kartos saityno priemonės (angl. *Web 2.0*). Tai saityno priemonės, suteikiančios galimybę naudoti laisvai publikuojamo turinio bazes, tinklaraščius, vikius, bendruomenių tinklus ir adresynus, RSS, AJAX technologijas, hibridus, laisvosios prieigos saityno paslaugas ir kitas interaktyvias sistemas (toliau darbe vadinsime internetinėmis priemonėmis). Nors šios priemonės buvo sukurtos ne edukaciniais tikslais, tačiau greitai jas imta taikyti visose ugdymo srityse: pamokose, studijose, nuotoliniame mokymesi. Tai darė didelę įtaką ugdymui, ypatingai el. mokymuisi.

El. mokymasis – tai mokymasis, kuris siekiant kokybės ir efektyvumo praturtinamas informacijos ir komunikacijos technologijomis (IKT), mokymosi procesas dažniausiai perkeliamas į virtualią erdvę. El. mokymasis, kuris yra praturtintas antrosios kartos saityno priemonėmis, vadinamas antrosios kartos el. mokymusi (angl. *E.learning 2.0*).

Antrosios kartos saityno priemonių poveikis mokymosi procesui vertinamas teigiamai dėl suteikiamų mokymosi veiklų lengvesnio atlikimo galimybių (Bower ir kt., 2010; Conde ir kt., 2012; Conole, Alevizou, 2010), dėl suteikiamų galimybių besimokantiesiems dalintis idėjomis (Kuswara, Richards, 2011), aktyviai dalyvauti bei lavinti kūrybiškumo įgūdžius (John, Sutherland, 2005; Redecker ir kt., 2009; Tess, 2013; Kirkwood, Price, 2013). Visos šios savybės yra būtinos siekiant personalizuoto mokymosi tikslų ir geresnių mokymosi proceso rezultatų.

Personalizuotos mokymosi aplinkos kūrimas parenkant besimokančiajam tinkamas internetines priemones yra sudėtingas ir aktualus šių dienų uždavinys. Dabartinis besimokantysis turėtų pats imtis iniciatyvos, būti atsakingas už mokymosi procesą, mokėti pasirinkti tinkamas mokymosi priemones (Siemens, 2005; Siemens, Downes, 2009; Ackermann, 2010; Kalaš, 2010; Filipčič, 2010), tačiau parama mokymosi metu taip yra labai svarbi. Besimokančiojo savarankiškai pasirinktos priemonės nebūtinai padės įgyvendinti siekiamų mokymosi tikslų ir veiklų optimaliausiu būdu. Kadangi besimokantysis neturi pakankamos patirties ir žinių, paieškos procesas gali pareikalauti daug pastangų ir laiko. El. mokymosi rekomendavimo sistemos gali atlikti pedagogo – patarėjo vaidmenį, nes jų žinių bazėse yra sukauptos ekspertų žinios ir sistemos rekomendavimas gali prilygti pedagogų patarimams, dažnai juos net pernokti. Mokymosi turinys ir priemonės rekomenduojamos naudojant įvairius informacijos surinkimo, aprašymo ir apdorojimo algoritmus.

Disertaciniame darbe išnagrinėti rekomendavimo sistemų ir jose naudojamų vartotojo profilių tipai, rekomendavimo būdai, šių sistemų taikymo galimybės personalizuotam mokymuisi, mokymosi proceso ir antrosios kartos saityno priemonių sąveika, pagrindinės savybės. Pateikiamas šio darbo autorės sudarytas antrosios kartos saityno priemonių komponavimo mokymosi procese metodas parenkantis tam tikram besimokančiajam priemonę atsižvelgus į mokymosi tikslus, norimą įgyvendinti mokymosi veiklą, teikiamą pirmenybę mokymosi turiniui bei bendravimo formai.

Nagrinėtoji dalykinė sritis aprašyta ontologijoje, o pasiūlyto metodo etapai įgyvendinti žiniomis grindžiamos rekomendavimo sistemos prototipe. Sukurtoji sistema rekomenduoja tam tikrą mokymosi stilių turinčiam besimokančiajam visas jos žinių bazėje esančias internetines priemones, kuriomis naudodamasis besimokantysis gali atlikti nurodytą mokymosi veiklą.

Pasiūlytą metodą įvertino parinkti ekspertai – buvo įsitikinta metodo kokybe, t. y. tikslumu, tinkamumu ir našumu (laiko atžvilgiu) rekomenduojant internetines mokymosi priemones.

1.2. Tyrimo objektas

Antrosios kartos saityno priemonių naudojimas mokymuisi personalizuoti.

1.3. Tyrimo tikslas

Siekiant padėti besimokančiajam sparčiau ir tiksliau rasti tinkamas antrosios kartos saityno priemones, sukurti personalizuotą, atsižvelgus į besimokančiojo teikiamas pirmenybes mokymosi turiniui ir bendravimo formai, šių priemonių, tinkamų konkrečiai mokymosi veiklai atlikti, parinkimo **metodą** ir jį įgyvendinantį žiniomis grindžiamos rekomendavimo sistemos **prototipą**.

1.4. Darbo uždaviniai

1. Ištirti personalizuoto el. mokymosi technologinius ypatumus: rekomendavimo sistemų taikymo personalizuotam mokymuisi galimybes bei šių sistemų komponentus.
2. Atlikti antrosios kartos saityno priemonių, tinkamų mokymosi veikloms įgyvendinti, parinkimo metodų analizę.
3. Sukurti antrosios kartos saityno priemonių komponavimo personalizuoto mokymosi procese metodą, kai atsižvelgiama į besimokančiųjų mokymosi stilius.
4. Sukurti pasiūlytą metodą įgyvendinantį sistemos prototipą.
5. Atlikti pasiūlytą metodą įgyvendinančios sistemos prototipo ekspertinį vertinimą.

1.5. Tyrimų metodai

Rengiant analitinę disertacijos dalį buvo atlikta mokslinės literatūros sisteminė analizė: informacijos paieškos, sisteminimo, analizės, lyginamosios analizės ir apibendrinimo metodas. Buvo analizuojami: antrosios kartos saityno priemonių taikymo mokymuisi, rekomendavimo sistemų taikymo personalizuotam mokymuisi įgyvendinti būdai. Remiantis analize ir siekiant darbe iškelto tikslo, buvo pasirinktas vienas iš žiniomis grindžiamos rekomendavimo sistemos naudojamo žinių aprašymo būdų – ontologija. Sudarant ontologiją daugiausia buvo remtasi METHONTOLOGY (Fernández ir kt., 1999) ontologijos sudarymo metodu.

Atliekant pasiūlyto internetinių priemonių atrankos metodo eksperimentinį vertinimą naudoti ekspertų apklausos, apibendrinamieji metodai, o sudarytojo metodo kokybei vertinti – neraiškiųjų skaičių daugiakriterinis analizės vertinimo metodas.

1.6. Mokslinis naujumas

Mokslo literatūroje aptinkama tyrimų, kuriuose nagrinėjama, į kokius aspektus reikėtų atsižvelgti parenkant internetines priemones tam tikrai mokymosi veiklai įgyvendinti. Tačiau trūksta rekomendacijų, kaip šie aspektai nulemia tinkamos priemonės parinkimą, kokiu būdu atsižvelgiama į individualius besimokančiojo poreikius.

Rengiant disertaciją buvo gauti šie informatikos inžinerijos mokslui nauji rezultatai:

1) Sukurtas metodas, kuris nuo kitų internetinių priemonių, tinkamų konkrečiai mokymosi veiklai įgyvendinti, parinkimo metodų skiriasi personalizuota priemonių paieška atsižvelgiant į mokymosi turiniui ir bendravimo formoms teikiamas pirmenybes. Sukurtas ir įdiegtas metodas, leidžia tiksliai, tinkamai ir greitai parinkti internetines priemones personalizuotam mokymuisi.
2) Dalykinės srities žinioms formaliai apibrėžti buvo naudota OWL DL ontologijos kalba, grįsta deskriptyviosios logikos teorija, o sudaryta dalykinės srities ontologija remiasi mokymosi veiklos ir internetinių priemonių funkcijų komponentų sąryšiu.

1.7. Ginamieji teiginiai

1. Žiniomis grindžiamos rekomendavimo sistemos žinių aprašymo ontologija būdas yra taikytinas mokymosi personalizavimo srityje, būtent, besimokančiojo mokymosi veikloms galima parinkti tinkamiausias priemones atsižvelgus į jo mokymosi stilių.
2. Sukurtas antrosios kartos saityno priemonių parinkimo metodas padeda tiksliai, tinkamai ir greitai rasti pasirinktoms mokymosi veikloms atlikti tinkamas priemones.

1.8. Praktinė darbo reikšmė

1. Išnagrinėti personalizuoto el. mokymosi technologiniai ypatumai ir funkcijos, apžvelgti rekomendavimo sistemų veikimo principai ir jų taikymo personalizuotam mokymuisi patirtis. Ištirtos įvairių IKT ir internetinių priemonių panaudojimo galimybės ir metodai mokymosi procese. Analizė leido sudaryti internetinių priemonių parinkimo personalizuotam mokymuisi metodą.
2. Nagrinėtos dalykinės srities žinios, aprašytos OWL kalba, gali būti naudotinos įvairiose rekomendavimo sistemose, siūlymus pateikiant atsižvelgus ne tik į mokymosi turinio formą bet ir į mokymosi veiklas.
3. Rekomendavimo sistemos prototipe įgyvendintas pasiūlytas metodas gali būti (jį praplėtus) įgyvendintas ir realioje el. mokymosi sistemoje.
4. Pasiūlyto metodo ekspertinis aprobavimas parodė, kad metodas yra taikytinas realiame kontekste: tinkamas, tikslus ir našus laiko atžvilgiu. Naudodamos šį metodą pedagogikos praktikoje švietimo įstaigos galėtų pasiekti geresnių personalizuoto mokymosi rezultatų. Teisingas metodo naudojimas leistų pagerinti mokymosi kokybę, motyvaciją, praktines žinias taikyti su teorinėmis.

1.9. Darbo struktūra

Darbą sudaro: terminų ir santrumpų žodynėlis, įvadas, trys pagrindinės dalys (1 pav.), bendrosios išvados ir rezultatai, cituotos literatūros ir standartų sąrašas, priedai.

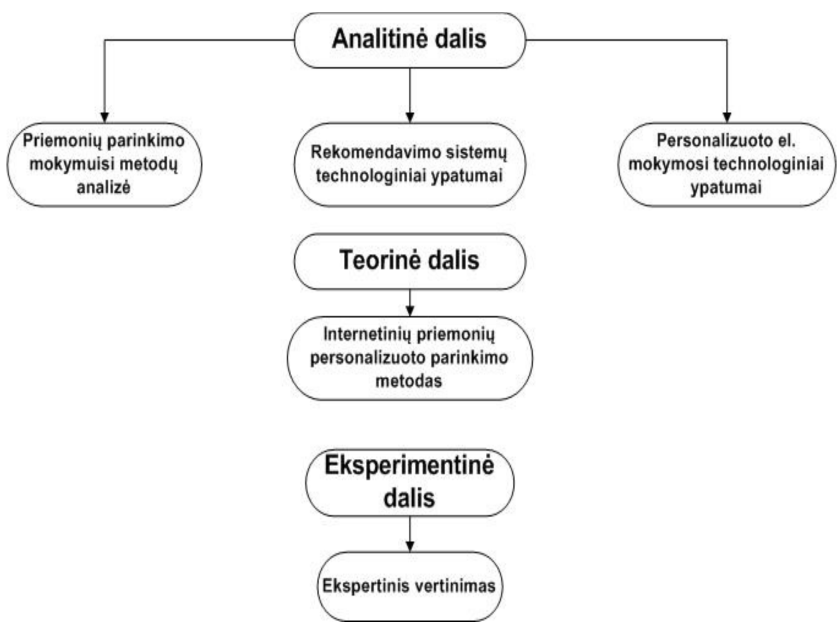
Pirmojoje dalyje – įvade – aprašomas darbo aktualumas, iškeliamas darbo tikslas ir uždaviniai, darbo mokslinis naujumas ir praktinė darbo reikšmė, pateikiamas autorės mokslinių publikacijų disertacijos tema ir mokslinėse konferencijose skaitytų pranešimų disertacijos tema sąrašas.

Antrojoje dalyje analizuojami moksliniai literatūros šaltiniai, susiję su el. mokymosi personalizavimo tema: analizuojamos personalizavimo galimybės, rekomendavimo sistemų ypatumai, besimokančiojo profilio sudarymo problemos, internetinių priemonių taikymo galimybės ir modeliai mokymosi proceso kokybei ir besimokančiojo motyvacijai gerinti.

Trečiojoje dalyje nagrinėjamas mokymosi proceso ir tinkamų internetinių priemonių parinkimo personalizuotam mokymuisi metodas ir metodo taikymo pavyzdys. Sukurtasis metodas padeda parinkti besimokančiajam (atsižvelgus į jo mokymosi stilių) internetinę priemonę, tinkamą tam tikrai mokymosi veiklai įgyvendinti.

Ketvirtojoje dalyje aprašomas trečiojoje dalyje pasiūlyto metodo kokybės, įgyvendinto rekomendavimo sistemos prototipe, ekspertinis vertinimas, apibendrinti rezultatai ir pateiktos bendrosios išvados.

Bendra disertacijos apimtis yra 147 puslapiai.



1 pav. Pagrindinės disertacijos dalies struktūra

1.10. Darbo publikavimas ir aprobavimas

Disertacijos rezultatai pateikti šešiose mokslinėse publikacijose: penkiuose recenzuojamuose periodiniuose leidiniuose, viename mokslinės konferencijos darbų leidinyje. Disertacijos rezultatai pristatyti septyniose tarptautinėse ir nacionalinėse konferencijose.

BENDROSIOS IŠVADOS IR REZULTATAI

1. Ištyrus antrosios kartos saityno priemones ir rekomendavimo sistemų taikymo personalizuotam mokymuisi galimybes, nustatyta, kad:

   1.1. Antrosios kartos saityno priemonės mokslinėse publikacijose yra skirstomos pagal įvairius kriterijus, tačiau visuotinai priimtos ir pagrįstos klasifikacijos nėra, ta pati priemonė gali turėti įvairių funkcijų ir valdyti daugelį skirtingų objektų. Šiame darbe pateiktas antrosios kartos saityno priemonių klasifikavimo būdas padeda vartotojui orientuotis antrosios kartos saityno priemonių gausoje ir išskirti jų teikiamas galimybes. Pateikiamas skirstymas į tris grupes: 1) artefaktų valdymo, 2) komunikavimo ir 3) imitavimo. Tai įgalina sudaryti antrosios kartos saityno priemonių taksonomiją pagal priemonių taikymo galimybes ir valdomus objektus, komunikavimo formą ir imituojamo proceso tipą.

   1.2. Publikacijose dažniausiai nagrinėjamas mokymosi kokybės gerinimas į mokymosi procesą įtraukus antrosios kartos saityno priemones ir atsižvelgus į jų tinkamumą konkrečiai mokymosi veiklai įgyvendinti – nurodant mokymosi tikslus ir metodus, pageidaujamą bendravimo ir veikimo sąveikos formą bei laiką. Tokiu atveju tik iš dalies atsižvelgiama į besimokančiojo poreikius ir savybes. Šiame darbe siūloma mokymąsi personalizuoti atsižvelgus į besimokančiojo teikiamą pirmenybę mokymosi turinio ir bendravimo formai, remiantis VARK mokymosi stilių modelio teorija.

   1.3. Rekomendavimo sistemos tinka mokymuisi personalizuoti, siūlant mokymosi turinį ir priemones atsižvelgus į besimokančiojo poreikius. Tokiu būdu gerinama mokymosi kokybė ir besimokančiojo motyvacija. Žiniomis grindžiamos rekomendavimo sistemos siūlo elementus gretinant jų savybes su vartotojo profilyje aprašytomis savybėmis (profilis el. mokymosi sistemose sudaromas remiantis mokymosi stilių teorija). Rekomendavimui naudojamos dalykinės srities žinios ir vartotojo profilis aprašomi ontologija, tokiu būdu užtikrinamas pakartotinis sukauptų žinių panaudojimas, kuris tinka ir žmonėms, ir programiniams moduliams.

2. Remiantis antrosios kartos saityno mokymuisi skirtomis priemonėmis, rekomendavimo sistemų taikymo personalizuotam mokymuisi analize bei tyrimais ir sukaupta praktine patirtimi, pasiūlytas antrosios kartos saityno priemonių komponavimo mokymosi procese metodas:

   2.1. Kuris padeda parinkti priemones, tinkančias besimokančiojo nurodytai mokymosi veiklai įgyvendinti atsižvelgus į jo mokymosi stilių, t. y. į mokymosi turinio ir bendravimo formai teikiamą pirmenybę. Tokiu būdu mokymosi procesas yra personalizuojamas.

   2.2. Kurio elementai formaliai užrašyti ontologija, leidžia dalykinės srities žinias panaudoti šį metodą įgyvendinančioje rekomendavimo sistemoje.

3. Atlikus darbe pasiūlyto antrosios kartos saityno priemonių komponavimo mokymosi procese metodo, įgyvendinto rekomendavimo sistemos prototipe, ekspertinį vertinimą, nustatyta, kad:

   3.1. Sistemos pateikiami rezultatai yra tikslūs – rekomenduojamos priemonės yra tinkamos nurodytoms mokymosi veikloms įgyvendinti, t. y. siūlomos priemonės suteikia galimybę nurodytam edukaciniam veiksmui atlikti norimu laiku ir esant norimam besimokančiųjų skaičiui, o priemonių valdomi artefaktai yra tinkami konkrečiam besimokančiajam, atsižvelgus į jo mokymosi stilių;

3.2. Sistemos veikimas yra tinkamas, t. y. visiškai atitinka pasiūlytą metodą ir veikia, kaip numatyta – sistema personalizuotai rekomenduoja priemones;

3.3. Naudojantis sukurta rekomendavimo sistema, personalizuotam mokymuisi tinkančias internetines priemones galima rasti greičiau nei sistemos nenaudojant;

3.4. Pasiūlytas metodas ir jį įgyvendinantis prototipas yra geros kokybės, pagal tikslumo, tinkamumo ir našumo kriterijus – atitinka 81,4 proc. absoliučios kokybės.

TRUMPOS ŽINIOS APIE AUTORĘ

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Technological sciences, informatics engineering (07 T)

ANITA JUŠKEVIČIENĖ
ANTROSIOS KARTOS SAITYNO PRIEMONĖS MOKYMUISI
Daktaro disertacijos santrauka
Technologijos mokslai, informatikos inžinerija (07 T)