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The Use of the Intelligent Library and Tutoring System at All Stages of a Building Life Cycle

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Intelligent Library and Tutoring System for Brita in PuBs Project (ILTS-BPP) developed by the authors have the ability to personalize, maximum-reuse, index, analyze and integrate valuable information and knowledge from a wide selection of existing sources in all building life cycle stages. A number of tightly integrated search components (text search, audio search and video search) can be used. Such search possibilities ensure that stakeholders from construction and real estate industry can take advantage of quickly retrieving the most relevant information from the available content that has already been developed and approved for different manuals, handbooks, directives, research, normative documents, databases of best practice and other sources. We suppose that the intelligent libraries and tutoring systems will become a practical knowledge storehouse and will offer intelligent opportunities for learners in construction and real estate industry. The library of e-learning modules is individualized, can operate in distributed universities and institutions and can provide learners withdifferent forms of content.

Keywords: *building life cycle, construction and real estate, e-Libraries, e-Learning, Brita in PuBs project, intelligent systems*.

Introduction

A building life cycle consists of seven closely interrelated stages: brief, design, construction, maintenance, facilities management, demolition and utilisation. A building life cycle may have a lot of alternative versions. These variants are based on the alternative brief, design, construction, maintenance, facilities management, demolition, utilisation processes and their constituent parts.

An intelligent library have the ability to personalize, maximum-reuse, index, analyze and integrate valuable information and knowledge from a wide selection of existing sources in all building life cycle stages. A number of tightly integrated search components (text search, audio search and video search) can be used. Such search possibilities ensure that stakeholders from construction and real estate industry can take advantage of quickly retrieving the most relevant information from the available content that has already been developed and approved for different manuals, handbooks, directives, research, normative documents, databases of best practice and other sources. Although an intelligent library can allow users to type queries in all languages, word meaning, words frequency and combination when the developed search engine's only purpose is to retrieve documents or their parts based on a keyword search.

Searching, finding, indexing, selecting and integrating of required construction and real estate information and knowledge (lessons learned, training, analogies (best practices, law and directives, reports, industry practices, case studies, just in time training, market analyses), models, regulations/policies/guidance (historical baseline, communication, policies and guidance), new initiatives, e-services (Ostasius & Petraviciute, 2010), e-business (Gatautis, & Vitkauskaite, 2009), e-procurement (Vitkauskaite, & Gatautis, 2008), web services (Gatautis, & Vitkauskaite, 2008), e-government (Colesca, 2009), estimating tools and techniques, etc.) is providing sizeable supplementary value. Many organizations function in the infinite information universe, incapable to access and analyse all valuable information that already exists.

Tacit Construction and Real Estate Knowledge Base of Best Practice (TCREKBBP) consists of informal and unrecorded procedures, practices and skills. This "how-to" knowledge is essential because it defines the competencies of employees. TCREKBBP is of value to organizations to the extent that it can codify these "best practices", store them, search and find them upon demand according to a set of keywords. It shapes tacit knowledge for a concrete project. Because of the orientation toward unique projects, much knowledge in the construction and real estate industry is experience-based and tacit. The knowledge needs are dynamic, depending on the task or the problem. Nevertheless, the typical strategy for knowledge management is to make knowledge explicit and store it as databases. Organizations have been successful at collecting and storing explicit information in enterprise databases but they are poor at searching, finding and integrating useful information and knowledge. Consequently, organizations professionals find it difficult to reuse core experts' knowledge for highly knowledge-intensive construction and real estate activities. This situation calls for better collecting and disseminating tacit knowledge from experts' brains to achieve higher quality construction and real estate projects. An enormous volume of construction innovation knowledge is generated during the phases of brief, design, planning, construction, maintenance, facilities management, demolition and utilisation of a facility. Throughout the whole life cycle of a project, organizations rely on their experiences, professional intuition and/or other forms of tacit knowledge to accomplish satisfactory work. In order to develop a tacit knowledge base of best practice, its economic, technical, qualitative, technological, social, legal, infrastructure and other aspects must be analysed. The diversity of aspects being assessed should follow the diversity of ways of presenting data needed for decision-making. Therefore, intelligent library can be used for the searching, finding, indexing, selecting and integrating of above most relevant information and knowledge for the life cycle stakeholders of a buildings.

Intelligent library system for a tacit knowledge base of construction experts and communities of practice

The searching, finding, indexing, selecting and integrating of required information and knowledge in a Tacit Knowledge Base of Construction Experts is a very promising trend. In organizations, it is more likely that employees will work on similar projects, although there is no explicit link between them. Top managers generally assume the professionals in enterprises already possess tacit knowledge and experience for specific types of projects. This allows experienced workers to place their knowledge and experiences in the Tacit Knowledge Base of Construction Experts. Specifically, sophisticated construction methods are successfully applied by highly educated, experienced professionals on job sites. This knowledge is extremely important to organizations because, once a project is completed, professionals tend to forget it and start something new. Therefore, knowledge multifold utilization is a key factor in productively executing a construction project. One of the more successful initiatives for sharing tacit knowledge is Communities of Practice. These communities are designed to build a network of knowledgeable experts who work together to learn and solve complex problems when the solutions are needed. In general, they operate informally through virtual meetings, videoconferences or e-mail communications to exchange knowledge and work practices on topics of interest to the members. By using the Knowledge Base of Experts and intelligent library is it possible to search for experts and facilitates communication with those experts by using internet technology. Logging into the Knowledge Base of Experts and intelligent library, a professional in organization can search for an expert with the relevant knowledge and will communicate with him in real time by using virtual meetings, videoconferences or e-mail communications. As a result, a professional in an organization could receive direct tacit help from an expert who had recently experienced a similar problem. At the time of communication, experts' tacit knowledge will be transferred in the most appropriate forms and applied in construction and real estate processes. Their dialogue would be audited and stored in enterprise database systems to be searched by others. In this way, organizations extract valuable tacit knowledge from employees' brains and apply those assets to the work process. In this way, higher performance levels can be achieved theoretically by accelerating knowledge transfer processes.

For most organizations, potentially valuable information exists in multiple locations in multiple file formats, both within and outside the enterprise. Without access to this information, different stakeholders are faced with the daunting task of creating and continuously updating a body of knowledge to solve customer problems quickly, efficiently and accurately. Therefore, in future it is intended that intelligent library will help to exchange construction and building knowledge by using global databases and support the management and integration of design contributions from globally distributed partners.

Digital libraries and search engine rankings

As digital libraries become more popular, information and knowledge overload has become a pressing required literature searching problem. Problems with search on digital libraries will worsen as the amount of information and knowledge increases. Traditional digital libraries often index words and documents when learners think in terms of topics and subjects. As a result, learners cannot without problems determine how well a particular topic and subject is covered, or what types of searching will provide required information and knowledge.

Search engine rankings have been adopted in the most advanced intelligent libraries (Alexandrov *et al.* 2003; Chen, 2008, 2010; Escudero & Fuentes, 2010; García-Crespo *et al.* 2010; Garibay *et al.* 2010; Gutwin *et al.* 1999; Hsinchun *et al.* 1998; Hwang *et al.* 2010; Kaklauskas *et al*. 2006a, 2006b; Oard *et al.* 2008; Porcel & Herrera-Viedma, 2010; Ruch *et al*. 2007; Trnkoczy *et al.* 2006; Vega-Gorgojo *et al.* 2010; Wang, 2003) and tutoring systems (Ammar *et al.* 2010; Armani *et al.* 2000; Brusilovsky, 2000; Chen, 2009; Chen, 2011; Crowley *et al.* 2007; Day *et al*. 2007; Gasparetti *et al.* 2009; Gunel & Asliyan, 2010; He *et al.* 2009; Hsu *et al.* 2010; Lucence, 2005; Mao & Li, 2010; Phobun & Vicheanpanya, 2010; Pouliquen *et al*. 2005; Roll *et al.* 2011; Sarrafzadeh *et al.* 2008) recently. As part of the Illinois Digital Library Initiative project, the research proposes an intelligent personal spider (agent) approach to Internet searching, which is grounded on automatic textual analysis, general-purpose search and genetic algorithms (Hsinchun *et al.* 1998). Pouliquen *et al*. (2005) use parsing techniques to extract information from the text, and provide a proper semantic indexation which is used by a medical-specific search engine. Day *et al*. (2007) use the Jakarta Lucene full text indexer to index the full text of the textbook. Jakarta Lucene is a high-performance, full-featured text search engine library written entirely in Java. The technology is suitable for nearly all applications that require full-text search. It is also readily available and has a good API for our needs. ITA (Pouliquen *et al*. 2005) index the chapters, sections, and subsections of the textbook. Highlighter is used to highlight the index context. Finally, the ITA provides reading recommendations for students via the chapter similarity function.

However, most of above mentioned intelligent libraries and intelligent tutoring systems with search engine rankings cannot select chapters (sections, paragraphs) of a specific text which are the most relevant to a student, cannot integrate them into learner-specific alternatives of teaching material and cannot select the most rational alternative, i.e. cannot develop alternatives of training materials, perform multiple criteria analysis and select the most effective variant automatically. However, an Intelligent Library and Tutoring System for Brita in PuBs project (ILTS-BPP) can perform the aforementioned functions (BRITA in PuBs, 2008). No one thought of above function before, so this attempt is the first (rare). The approach helps students to obtain suitably tailored material for an e-learning course. Above and other improvements are possible by using the ILTS-BPP.

The e-learning Master Degree studies *Construction Economics, Real Estate Management and Internet Technologies and Real Estate Business* were introduced at Vilnius Gediminas Technical University in 1999. There are currently 225 master students from all over Lithuania studying in the e-learning Master's Degree programs. ILTS-BPP also is used for these e-learning Master's Degree programs.

An Intelligent library and a tutoring system for Brita in PuBs project

The intelligent library (library of e-learning modules) in construction and a real estate sector should have the following functions:

- Customisation and personalization function. Learners are central to the library of e-learning modules and all efforts to develop e-learning modules should be based on the need to provide interesting, practical and innovative knowledge to learners. Customisation and personalization function serves students with various goals and characteristics: to access a steadily expanding amount of digital information and knowledge with the minimum efforts according to explicit and implicit learner requirements; to personalize information access to digital content at the levels of content selection, content presentation, services and content volume.
- Cooperation function. The library of e-learning modules must provide easy communication among students, tutors, researchers, construction and real estate industry professionals, etc. on topics that are of mutual interest.
- Maximum-reuse efforts, economy of scale and extensibility function. Within the Brita in PuBs Project, the library of e-learning modules should be created by broad variety of participating universities and institutions, which would interconnect modules across Europe and Asia and support for easy sharing and reuse of materials and integrate their contents.
- Integral multimedia function. The library of e-learning modules should manage all multimedia forms (electronic format of textbooks, video, audio as well as computer-software, computer learning systems) integrally.
- Notification function. Notification when new multimedia of importance to the learner is added to a e-learning modules library.
- Function of support of cooperation within communities of best practice.

Some above functions are briefly analyzed as follows.

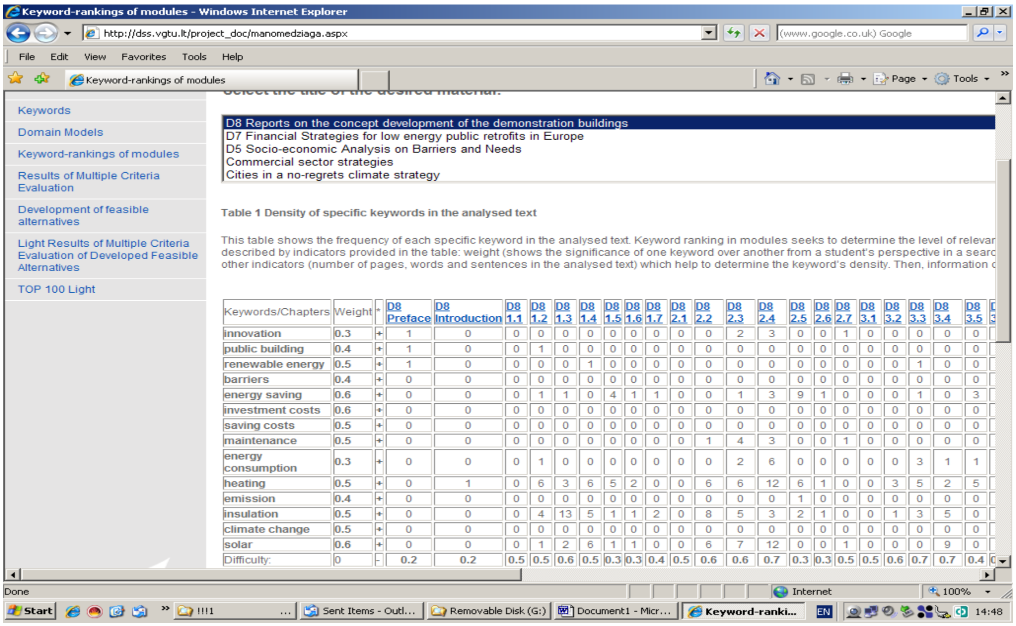
Indexing and multi-variant design as a core component of a module large-scale content integration

Indexing often is used to refer to the automatic selection and compilation of 'meaningful' keywords from e-textbooks into a list that can be used by a search system to retrieve texts. This list is more properly called a concordance. As this procedure involves no intellectual effort indexers distinguish their own work by calling it intellectual indexing, manual indexing, human indexing or back-of-book-style indexing. Indexing also means the intellectual analysis of e-textbooks to identify the concepts represented in the document and the allocation of descriptors to allow these concepts to be retrieved. During indexing the Indexing Sub-system visit definite Brita in PuBs Project modules and collects information/keywords about it (BRITA in PuBs 2008). Intelligent copy and paste from many modules with retention of a link/reference to the module can be performed. Development of new module is performed by using a combination of knowledge found with the possibility of easy editing and integrating. Learners can use Indexing Sub-system for computer-assisted extraction of data from a text for their own purposes, making their work more efficient. As importantly, these data can then be reused and made useful for a large learners community: they can be incorporated (connected, interlinked) into a large distributed knowledge base.

Table 1 shows the frequency of each specific keyword in the analysed text. Keyword ranking in modules seeks to determine the level of relevance of chapters and sections for student's needs. The level of relevance to student's needs can be defined by the term "Keyword density and significance" as described by indicators provided in the table: weight (shows the significance of one keyword over another from a student's perspective in a search for specific learning material), difficulty of a text (the level of difficulty is determined on the basis of previous examination results related to a specific topic) and other indicators (number of pages, words and sentences in the analysed text) which help to determine the keyword's density. Then, information describing the usefulness of the analysed text for a learner's needs is summarised in Table 1. Also, the relevance of a text to a student's learning needs is described by the presence of different keywords in one sentence (see Table 2). The occurrence of several different keywords that are specified by a student in the same sentence shows higher relevance of the text to the learner's needs.

Table 1

Density of specific keywords in the analysed text



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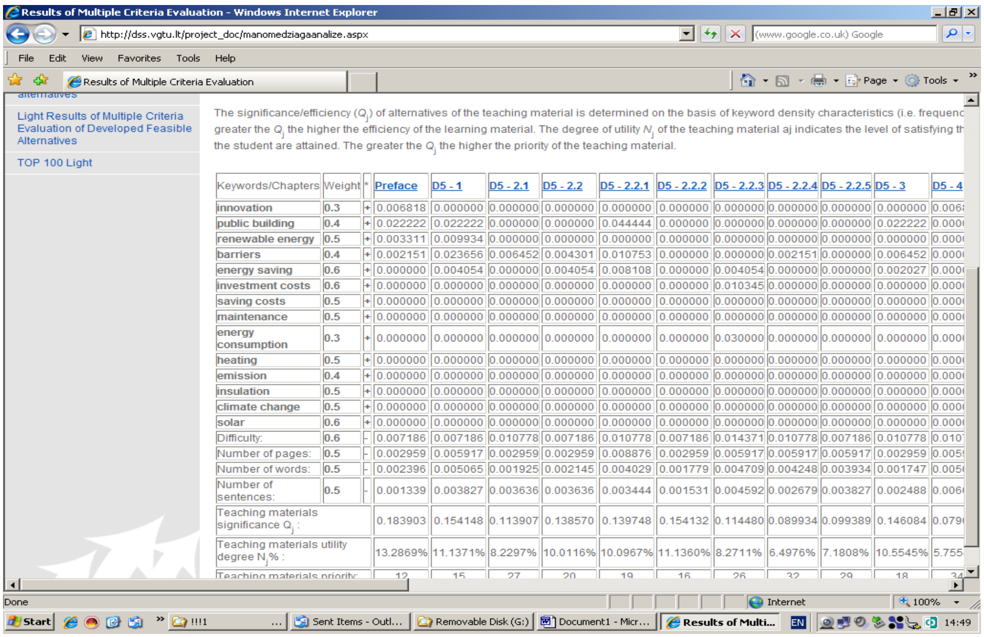
Keywords/Chapters	Weight	*	D8 Preface	D8 Introduction	D8 1.1	D8 1.2	D8 1.3	D8 1.4	D8 1.5	D8 1.6	D8 1.7	D8 2.1	D8 2.2	D8 2.3	D8 2.4	D8 2.5	D8 2.6	D8 2.7	D8 3.1	D8 3.2	D8 3.3	D8 3.4	D8 3.5
innovation	0.3	+	1	0	0	0	0	0	0	0	0	0	0	2	3	0	0	1	0	0	0	0	0
public building	0.4	+	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
renewable energy	0.5	+	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
barriers	0.4	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
energy saving	0.6	+	0	0	0	1	1	0	4	1	1	0	0	1	3	9	1	0	0	0	1	0	3
investment costs	0.6	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
saving costs	0.5	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
maintenance	0.5	+	0	0	0	0	0	0	0	0	0	0	1	4	3	0	0	1	0	0	0	0	0
energy consumption	0.3	+	0	0	0	1	0	0	0	0	0	0	0	2	6	0	0	0	0	0	3	1	1
heating	0.5	+	0	1	0	6	3	6	5	2	0	0	6	6	12	6	1	0	0	3	5	2	5
emission	0.4	+	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
insulation	0.5	+	0	0	0	4	13	5	1	1	2	0	8	5	3	2	1	0	0	1	3	5	0
climate change	0.5	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
solar	0.6	+	0	0	0	1	2	6	1	1	0	0	6	7	12	0	0	1	0	0	0	9	0
Difficulty:	0	-	0.2	0.2	0.5	0.5	0.6	0.5	0.3	0.3	0.4	0.5	0.6	0.6	0.7	0.3	0.3	0.5	0.5	0.6	0.7	0.7	0.4

Legend **-** The first column of the Table provides the keywords under evaluation; the second column provides the weight of the keywords. The Table's third column specifies whether the minimising or maximising value is the best. From the fourth column onwards, numbers of paragraphs are provided with references to full texts and the frequency of iterated keywords.

Table 2

Results of multiple criteria evaluation



The significance/efficiency (Q_j) of alternatives of the teaching material is determined on the basis of keyword density characteristics (i.e. frequenc
greater the Q_j the higher the efficiency of the learning material. The degree of utility N_j of the teaching material aj indicates the level of satisfying th
the student are attained. The greater the Q_j the higher the priority of the teaching material.

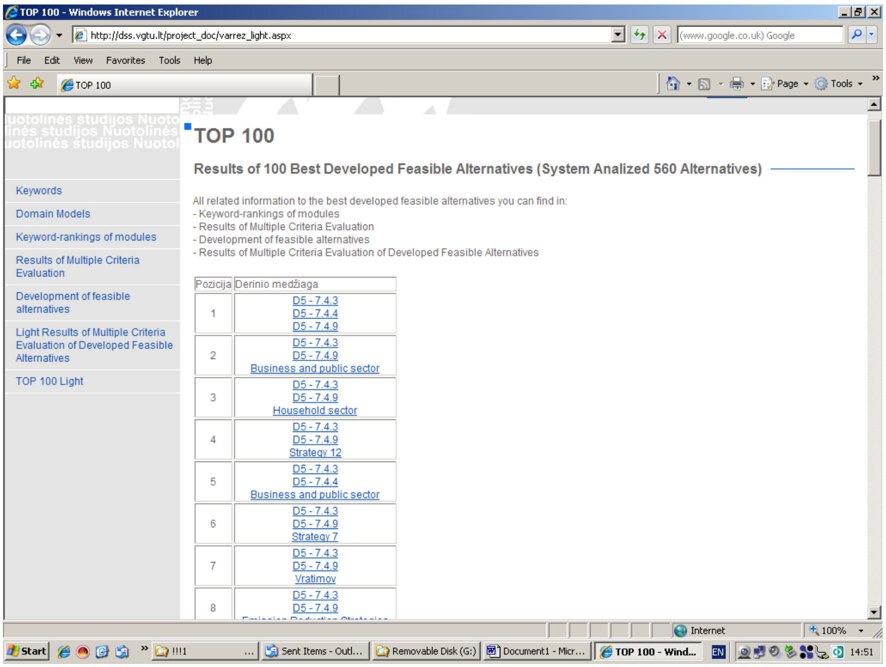
Keywords/Chapters	Weight	*	Preface	D5 - 1	D5 - 2.1	D5 - 2.2	D5 - 2.2.1	D5 - 2.2.2	D5 - 2.2.3	D5 - 2.2.4	D5 - 2.2.5	D5 - 3	D5 - 4
innovation	0.3	+	0.006818	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006
public building	0.4	+	0.022222	0.022222	0.000000	0.000000	0.044444	0.000000	0.000000	0.000000	0.000000	0.022222	0.000
renewable energy	0.5	+	0.003311	0.009934	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
barriers	0.4	+	0.002151	0.023656	0.006452	0.004301	0.010753	0.000000	0.000000	0.002151	0.000000	0.006452	0.000
energy saving	0.6	+	0.000000	0.004054	0.000000	0.004054	0.008108	0.000000	0.004054	0.000000	0.000000	0.002027	0.000
investment costs	0.6	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010345	0.000000	0.000000	0.000000	0.000
saving costs	0.5	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
maintenance	0.5	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
energy consumption	0.3	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.030000	0.000000	0.000000	0.000000	0.000
heating	0.5	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
emission	0.4	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
insulation	0.5	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
climate change	0.5	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
solar	0.6	+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
Difficulty:	0.6	-	0.007186	0.007186	0.010778	0.007186	0.010778	0.007186	0.014371	0.010778	0.007186	0.010778	0.010
Number of pages:	0.5	-	0.002959	0.005917	0.002959	0.002959	0.008876	0.002959	0.005917	0.005917	0.005917	0.002959	0.005
Number of words:	0.5	-	0.002396	0.005065	0.001925	0.002145	0.004029	0.001779	0.004709	0.004248	0.003934	0.001747	0.005
Number of sentences:	0.5	-	0.001339	0.003827	0.003636	0.003636	0.003444	0.001531	0.004592	0.002679	0.003827	0.002488	0.006
Teaching materials significance Q_j :			0.183903	0.154148	0.113907	0.138570	0.139748	0.154132	0.114480	0.089934	0.099389	0.146084	0.079
Teaching materials utility degree N_j% :			13.2869%	11.1371%	8.2297%	10.0116%	10.0967%	11.1360%	8.2711%	6.4976%	7.1808%	10.5545%	5.755
Teaching materials priority:			12	15	27	20	19	16	26	32	29	18	34

The significance/efficiency (Q_j) of alternatives of the teaching material is determined on the basis of keyword density characteristics (i.e. frequency of each specific keyword, weight, difficulty of a text, number of pages, words and sentences in the analysed text). Significance Q_j of the learning material aj indicates the satisfaction degree of requirements and goals pursued by the students, e.g. the greater the Q_j the higher the efficiency of the learning material.

The degree of utility N_j of the teaching material aj indicates the level of satisfying the needs of an actual student. The more learning goals that are achieved and the more important they are, the higher the degree of the teaching material's utility. The degree of the teaching material's utility reflects the extent to which the goals pursued by the student are attained. The greater the Q_j the higher the priority of the teaching material (see Table 3).

Table 3

Results of 100 best developed feasible alternatives



ILTS-BPP can display previously covered keywords that might be used for search required knowledge. The tutor can add additional keywords to this list. Also the search is possible by any combination of keywords. Using the keywords provided by a student and some criteria delivered by a Tutor and Testing Model, the system formulates a number of alternatives for an optional module. These alternatives are composed from the sections or components of many different modules matched in a certain way. The selection of keywords and determination of their importance is not as simple as it seems. The numbers of feasible alternatives can be as large as 100,000. The received information is used for action plans, i.e. *mini curricula* that are used to lead the learner/student to rationally accomplish the learning process. The *Mini Curricula* are adapted to individual learner's needs, depending on their knowledge level, age, study and learning styles and difficulties.

Customisation and personalization in Student Model

As constantly increasing amounts of information and knowledge in the library of e-learning modules become available to a growing number of learners, it becomes very difficult for students to find the information and knowledge they need. Moreover, different students with different education, objectives, requirements and priorities may expect particular and individualized ILTS-BPP behaviour. What distinguishes the personalized ILTS-BPP from a traditional construction and real estate e-libraries systems is the existence of Student Model that stores data that is specific to each individual learner. These learner profiles let the ILTS-BPP adapt its behaviour to the education, objectives, requirements and priorities of learners.

In general, ILTS-BPP performance may be adapted, i.e., personalized, at different levels: at the content selection, content presentation (electronic format of textbooks, video, audio, computer-software, computer learning systems), services (life long learning, master degree studies, PhD degree studies, etc.), content volume (i.e. 50, 100 or 250 pages of textbook) or interaction level, taking into account the education, objectives, requirements and priorities of learners. For example, various learners are provided with diverse content according to their requirements and priorities. The same content can be offered to different learners in a summarized or an extended form or in different multimedia. Various learners may have access to different services, which may be customized according to learner requirements and priorities.

The Student model stores data that is specific to each individual student. The Student Model is used to accumulate information about the education of a student, his or her study needs, training schedule, results of previous tests and study results.

Decision Support Sub-system, Database of Computer Learning Systems, Statistical Information Streams and the Tutor and Testing Model

The Decision Support Sub-system is mostly used in all components of the ILTS-BPP (Intelligent Library, Student Model, Tutor and Testing Model, and Database of Computer Learning Systems) by giving different levels of intelligence to these components. The Decision Support Sub-system was developed by applying multiple criteria decision making methods that were created by the author, i.e. a method of complex determination of the weight of the criteria taking into account their quantitative and qualitative characteristics; a method of multiple criteria complex proportional evaluation of the alternatives; a method of defining the utility and market value of an alternatives; and a method of multiple criteria multivariant design of an alternatives. The Decision Support Sub-system assists and strengthens some kinds of decision processes.

The database of computer learning systems enables the use of the following Web-based computer learning systems (Kaklauskas *et al*. 2006a, 2006b, 2007c, 2009, 2010a; Naimavičienė *et al*. 2007; Urbanavičienė *et al.* 2009; Zavadskas *et al.* 2010a, 2010b): construction, real estate, facilities management, international trade, ethics, innovation, sustainable development and building refurbishment, etc. The above systems have been developed by using multiple criteria methods (Banaitiene *et al.* 2008; Kaklauskas *et al.* 2007a, 2007b, 2010b; Kanapeckiene *et al.* 2010; Mickaitytė *et al.* 2007, 2008; Šliogerienė *et al.* 2009; Tupenaite *et al.* 2010; Turskis *et al.* 2009; Viteikienė & Zavadskas, 2007; Zavadskas *et al.* 2008, 2009, 2010c) as were developed by the authors.

Permanent streams of statistical information (information based on voice analysis of student answers, information on correct and incorrect answer, time distribution on every question, the number of times a student changed an answer to each question of a test, history on interaction between students and tutors) is integrated into the Tutor and Testing Model. The Tutor and Testing Model provides the function to process and integrate permanent data streams and provides access to this data to different stakeholders. ILTS-BPP provides appropriate mechanisms for online processing of these aggregated stream data. Statistical aggregated stream data are particularly important in the library of e-learning modules for all stakeholders for later improvement and development of e-library. For example, on the basis of available statistical information, it is possible to determine which topics are the most relevant to learners and what their presentation form should be (e-books, audio, video, etc.). Besides, weaknesses and strengths of existing modules could be determined, and this information could be used as a basis to provide specific recommendations how to improve these modules.

The Intelligent Library presents learning frames to the student. The Tutor and Testing Model provides a model of the teaching process and supports transition to a new knowledge state. For example, information about when to test, when to present a new topic, and which topic to present is controlled by the Tutor and Testing Model model. The Tutor and Testing Model reflect teaching experiences of associate professors and/or professors. The Student Model is used as an input to the Tutor and Testing Model so that the Tutor and Testing Model's decisions reflect the differing needs of each student in the optional modules. The Tutor and Testing Model formulates questions at various difficulty levels, specifies sources for additional studies and helps to select literature and multimedia for further studies and a computer learning system to be use during studies.

A student can select the level of difficulty at which teaching will take place. The Tutor and Testing Model compares the knowledge possessed by a student (test before studies) and knowledge obtained by a student during studies (test after studies) and then it performs a diagnosis based on the differences. By collecting information on the history of a student's responses, the Tutor and Testing Model provides feedback and helps to determine strengths and weaknesses of a student's knowledge, and his/her new knowledge obtained during studies is summarized and then various recommendations and suggestions are provided.

The system provides information on the testing process in a matrix and a graphical form: information on correct and incorrect answer, time distribution on every question, and the number of times a student changed the an answer to each question of a test, etc.

Conclusions

Most advantage construction and real estate libraries select, organize, retrieve, and transmit tacit and explicit information/knowledge. Different reports contained an explicit criticism of the libraries' focus on their specific collections and a recommendation to focus more on user needs. There is a need to overpass the key limitations in the development of traditional libraries, which have been developed for a particular content and a specific group of learners. We suppose that the future libraries will become a practical knowledge storehouse and will offer intelligent opportunities for people. In order to increase the efficiency and quality of Brita in PuBs project activities, an Intelligent Library and Tutoring System for Brita in PuBs project (ILTS-BPP) was developed. ILTS-BPP have the ability to personalize, maximum-reuse, index, analyze and integrate valuable information and knowledge from a wide selection of existing sources in all building life cycle.

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Intelektinės bibliotekos ir praktinio mokymo sistemos taikymas visuose pastato gyvavimo ciklo etapuose

Santrauka

Pastato gyvavimo ciklas apima septynis tarpusavyje glaudžiai susijusius etapus: koncepcinio planavimo, projektavimo, statybos, naudojimo, pastatų ūkio valdymo, griovimo ir utilizavimo. Pastato gyvavimo ciklas gali turėti daugelį alternatyvų. Šios alternatyvos sudarytos iš koncepcinio planavimo, projektavimo, statybos, naudojimo, pastatų ūkio valdymo, griovimo ir utilizavimo alternatyvių variantų. Didžiuliai duomenų, informacijos ir žinių kiekiai yra generuojami per visą pastato gyvavimo ciklą. Statybos įmonės, įgyvendindamos projektus, remiasi patirtimi, profesine intuicija ir kitomis neišreikštinėmis žiniomis. Norint sudaryti geriausios praktikos neišreikštinių žinių bazę, reikia išanalizuoti jos ekonominius, techninius, kokybinius, technologinius, socialinius, teisinius, infrastruktūrinius ir kitokius aspektus. Vertinamų aspektų įvairovė turi atsispindėti pateikiant informaciją, reikalingą sprendimams priimti. Todėl intelektinė biblioteka gali būti naudojama pastato gyvavimo ciklo interesų grupėms reikalingai informacijai ir žinioms ieškoti, joms indeksuoti, parinkti ir integruoti.

Pastaruoju metu elektroninės bibliotekos tampa vis populiaresnės, nuolatos daugėja jose teikiamos informacijos (Alexandrov *et al*., 2003; Chen, 2008, 2010; Escudero & Fuentes, 2010; García-Crespo *et al.,* 2010; Garibay *et al.,* 2010; Gutwin *et al*., 1999; Hsinchun *et al*. 1998; Hwang *et al.,* 2010; Kaklauskas *et al*., 2006a, 2006b; Oard *et al.,* 2008; Porcel & Herrera-Viedma, 2010; Ruch *et al*., 2007; Trnkoczy *et al*., 2006; Vega-Gorgojo *et al.,* 2010; Wang, 2003). Didėjant laikomos informacijos apimčiai, vis sunkiau surasti norimą medžiagą, t. y. susiduriama su paieškos efektyvumo problema. Žinomos intelektinės ir elektroninės bibliotekos sistemos negauna vartotojui tinkamiausios informacijos (skyrių, poskyrių, pastraipų) iš konkretaus elektroninio teksto, neintegruoja jo į vartotojui sudaromos informacinės medžiagos alternatyvas (išlaikant sąsają su originaliu tekstu), neišrenka naujai iš skirtingų informacinių šaltinių sudarytos integruotos racionaliausios informacinės medžiagos alternatyvos, t. y. automatizuotai nėra nustatomi atskirų informacijos šaltinių racionalūs skyriai/paragrafai/pastraipos nėra sudaromos, integruotos suminės tekstinės medžiagos alternatyvos, nėra nustatoma, daugiakriterinė analizė ir racionaliausios alternatyvos. Žinomos sistemos nėra lanksčios atliekant paiešką, kadangi neturi galimybės pritaikyti atrinktą informaciją konkrečiam vartotojui tiek pagal vartotojo tikslus ir poreikius, tiek pagal informacijos apimtį (Ammar *et al.,* 2010; Armani *et al*., 2000; Brusilovsky, 2000; Chen, 2009; Chen, 2011; Crowley *et al.,* 2007; Day *et al*., 2007; Gasparetti *et al.,* 2009; Gunel & Asliyan, 2010; He *et al.,* 2009; Hsu *et al.,* 2010; Lucence, 2005; Mao & Li, 2010; Phobun & Vicheanpanya, 2010; Pouliquen *et al*., 2005; Roll *et al.,* 2011; Sarrafzadeh *et al.,* 2008).

Autorių sukurta Intelektinė bibliotekos ir praktinio mokymo sistema Europos Sąjungos 6-osios bendrosios mokslinių tyrimų, technologinės plėtros ir demonstracinės veiklos programos (Framework-6) „Brita in PuBs“ projektui (ILTS-BPP) (BRITA in PuBs, 2008) gali būti taikoma visuose pastato gyvavimo ciklo etapuose ir asmeniškai parinkti, maksimaliai panaudoti, indeksuoti, analizuoti bei integruoti vertingą informaciją ir žinias iš įvairiausių turimų šaltinių. Sistemoje taikomi autorių sukurti daugiakriterinės analizės metodai, taikomi įvairiems uždaviniams spręsti (Banaitiene *et al.,* 2008; Kaklauskas *et al.,* 2007a, 2007b, 2010b; Kanapeckiene *et al.,* 2010; Mickaitytė *et al.,* 2007, 2008; Šliogerienė *et al.,* 2009; Tupenaite *et al.,* 2010; Turskis *et al.,* 2009; Viteikienė ir Zavadskas, 2007; Zavadskas *et al.,* 2008, 2009, 2010c). Renkant ir indeksuojant informaciją, duomenų bazėje teikiamos visos reikiamos elektroninės knygos. Vartotojas per sąsają įveda jam svarbiausius reikšminius žodžius ir nurodo kiekvieno žodžio reikšmingumą. Taip pat reikšminius žodžius galima pasirinkti iš reikšminių žodžių duomenų bazės, kurioje pateikiami dažniausiai vartojami reikšminiai žodžiai ir jų reikšmingumai. Per apribojimų įvedimo sąsają vartotojas taip pat gali nurodyti ieškomos medžiagos sudėtingumo lygį ir jo reikšmingumą. Ieškomos medžiagos sudėtingumo lygis įvertinamas pagal dešimties balų skalę. Pavyzdžiui, matematinės orientacijos modulių skyriai (matematiniai metodai, taikomi rinkos ir investicinei nekilnojamojo turto vertei nustatyti) kai kuriems vartotojams yra gana sudėtingi. Nustatant racionaliausią ieškomą medžiagą, jos sudėtingumo lygis ir jo reikšmingumas įvertinami kartu su kitais kriterijais. Racionaliausia informacija nustatoma modulyje indeksuojant tekstą, t. y. nustatoma, kiek ieškomi žodžiai (jų sinonimai) ar jų deriniai kartojasi tekste.

Žinomos intelektinės ir elektroninės bibliotekos bei paieškos sistemos nėra lanksčios atliekant paieškas, kadangi neturi galimybės pritaikyti atrinktą informaciją konkrečiam vartotojui (besimokančiam asmeniui, dėstytojui, statybos inžinieriui, nekilnojamojo turto plėtotojui, nekilnojamojo turto brokeriui ir t. t.) tiek pagal vartotojo tikslus ir poreikius, tiek pagal informacijos apimtį, nes šios sistemos automatizuotai neišrenka atskirų informacijos šaltinių sudedamųjų dalių (skyrių, poskyrių, pastraipų ir kitų dalių) ir neatlieka jų daugiakriterinės analizės nesudaro informacinės medžiagos alternatyvų

(dalyvaujant pačiam vartotojui bei išlaikant sąsają su originaliu tekstu), neišrenka naujos iš skirtingų informacinių šaltinių sudarytos integruotos racionaliausios informacinės medžiagos alternatyvos.

Be bendrų intelektinėms mokymo sistemoms komponentų – studento modelio, pedagoginio modelio, disciplinų duomenų bazės ir grafinės sąsajos, į sistemą įtrauktas sprendimų paramos posistemis, kompiuterinių mokymo sistemų duomenų bazė ir žinių vertinimo posistemis. Taikant studento modelį sudaroma galimybė pritaikyti mokymą prie studijuojančiojo poreikių ir žinių lygio. Sprendimų paramos posistemis taikomas visuose intelektinės mokymo sistemos komponentuose, suteikia jiems skirtingo lygmens intelektualumo savybių. Kompiuterinių mokymo sistemų duomenų bazė leidžia naudotis šiomis internetinėmis mokymo sistemomis: statybos, nekilnojamojo turto, pastatų ūkio valdymo, tarptautinės prekybos, etikos, inovacijų, subalansuotos plėtros, renovacijos ir kt. (Kaklauskas *et al*., 2006a, 2006b, 2007c, 2009, 2010a; Naimavičienė *et al*., 2007; Urbanavičienė *et al.,* 2009; Zavadskas *et al.* 2010a, 2010b). Taikant pedagoginį ir žinių vertinimo modelį pateikiamos kitas – mokymo proceso modelis, padedantis pasiekti kitą žinių lygmenį. Grafinė sąsaja sukuria efektyvų dialogą tarp sistemos ir vartotojo. Sistemoje galima naudoti kelis glaudžiai susijusius paieškos komponentus (teksto paieška, garso paieška ir vaizdo paieška). Statybos ir nekilnojamojo turto sektoriaus interesų grupėms tokios paieškos galimybės suteikia pranašumų, nes galima greitai gauti aktualiausią informaciją iš turimos medžiagos, kuri jau buvo sukurta ir patvirtinta – skirta įvairioms instrukcijoms, vadovėliams, direktyvoms, tyrimams, norminiams dokumentams, gerosios patirties duomenų bazėms ir kitiems šaltiniams.

Autoriai mano, kad intelektinės bibliotekos ir praktinio mokymo sistemos taps praktinių žinių saugyklomis, kurios asmeninėms studijuojantiems statybos ir nekilnojamojo turto dalykus pateiks intelektinių galimybių. Elektroninio mokymosi modulių biblioteka yra individualizuota, gali veikti plačiai pasklidusiuose universitetuose ir kitose institucijose, o studentai iš jos gali gauti įvairių formų turinį.

Raktažodžiai: *pastato gyvavimo ciklas, statyba ir nekilnojamasis turtas, el. bibliotekos, el. mokymas, „Brita in PuBs" projektas, intelektinės sistemos*.

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