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Creating Adaptive Environment for e-Learning Courses

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Abstract

In this paper we provide an approach to creating adaptive environment for e-learning courses. In the context of e-education, successful adaptation has to be performed upon learners' characteristics. Currently, modeling and discovering users' needs, goals, knowledge preferences and motivations is one of the most challenging tasks in e-learning systems that deal with large volumes of information. Primary goal of the research is to perform personalizing of distance education system, according to students' learning styles. Main steps and requirements in applying business intelligence techniques in process of personalization are identified. In addition, we propose generic model and architecture of an adaptive e-learning system by describing the structure of an adaptive course and exemplify correlations among e-learning course content and different learning styles. Moreover, research that dealt with application of data mining technique in a real e-learning system was carried out. We performed adaptation of our e-learning courses using the results from the research.

Keywords: adaptive e-learning content, personalized e-learning, clustering, learner's characteristics

1. Introduction

E-learning, as a key part of distance education, is realized by using modern technologies, particularly Internet. Currently, more complicated requests for projecting and implementation of e-learning systems are to appear. At the same time, global trends, dynamic environment, complexity of issue, obligate on high degree of effectiveness, adaptability, integration and coordination of all relevant processes. In that context, business intelligence and its tools (particularly data mining) can be recognized as fulfillment of demands for additional, undiscovered, knowledge and possibilities.

The term Business Intelligence (BI) presents a wide area of applications and technologies for gathering, storing, analyzing data to help in making better business decisions. More details about BI could be found in [17].

2. Adaptive e-learning system

Nowadays, slight modifications and supplements to e-learning systems are not enough to ensure successful e-learning outcomes, because other important elements for e-learning success are missing such as flexibility of the system, adaptability towards students needs, effective and official design of electronic content (e-content). The lack of adaptive learning environments or an environment with adaptive features is partly due to the concepts "one-size-fits-all". Namely, very often, e-learning courses have a problem of "universal size" as the same static content is presented to all students and objective is getting the learner online and 'into' the technology. A few researches proved that this type of e-learning system organization resulted in failure. Currently, the emphasis is moving toward learner oriented platforms and putting student's expectations, motivation, habits, learning styles, needs, etc. in centre of interest [10].

An e-learning system is considered to be adaptive [11] if it is capable of: monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and preferences out of the interpreted activities, appropriately representing these in associated models; and, finally, acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process. Since the system behavior adapts to a person, this kind of adaptation is also called personalization. Thus, adaptive e-learning system can be described as personalized system, which beside contents discovery and assembly, is able to provide adaptive course delivery, adaptive interaction, and adaptive collaboration support [11]. Personalized e-learning uses proactive learning strategy, which enable learner to control learning content, pace and scope. By analogy to [9] suggested solution for architecture of an adaptive e-learning hypermedia system is shown in figure 1.

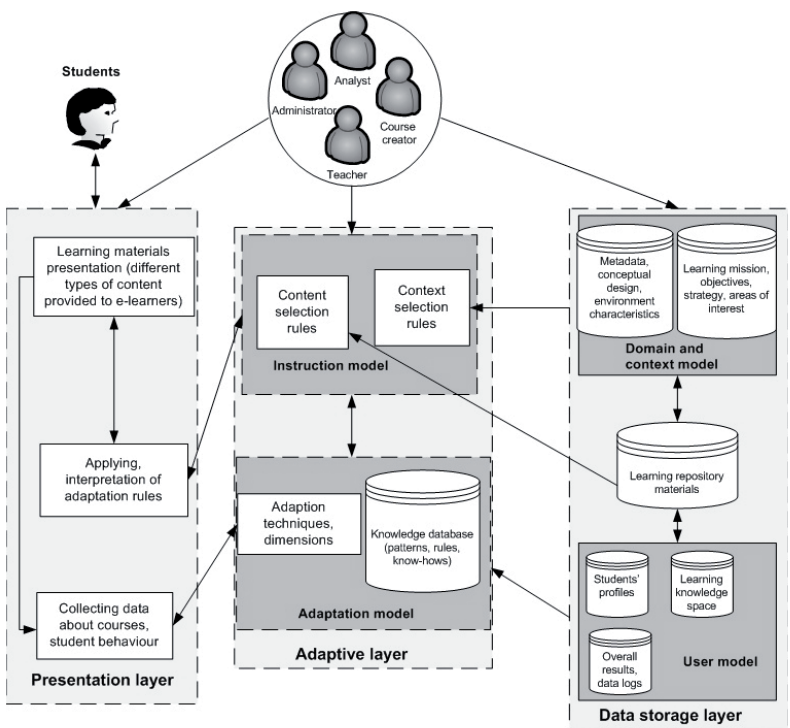

Figure 1. Three-layer architecture of adptive system

Our model consists of three layers. First layer includes data storages located in *domain* and *context model*. These are networks of connected objects related to e-learning mission, objectives hierarchy, metadata, conceptual design. Whole AHS relied on learning materials repository and *user (learner model)*. Learner model includes data bases about students' preferences and characteristics, behaviour and learning knowledge space. The instruction (pedagogical) and adaptation models specify the navigational design for an adaptive hypermedia application. Together with the presentation specification they tell *how* the adaptation should be performed, so they describe the dynamics ("flow") of the system. Knowledge base is in the center of middle layer. It possesses variety of applied patterns, rules and "know-how", which in combination with adaptive mechanisms should develop models. Inputs in the adaptation process are sets of students' preferences and profiles. Output of the adaptation is a sequence of content objects personalized to a learner. Naturally, on the top of the architecture are users. In order to generate effective e-learning systems, students have to be the most important part of the whole paradigm [16]. Personalized e-learning implies an active cooperative learning strategy that empowers the learner to be in control of the context and scope of learning experience [2].

Doubtless, the best performance in personalization would be achieved if we had information about learner's pre-knowledge, experience, usage of course content, but this issue becomes more complex if that type of data isn't available. Moreover, what if e-learning course is being created before students know nothing about the areas it deals with [12]. That problem is examined in the practical example of this paper.

Student modeling is the process whereby an adaptive learning system creates and updates a student model by collecting data from several sources implicitly (observing user's behavior) or explicitly (requesting directly from the user). Traditionally, most of student modeling systems have been limited to maintain assumptions related with student's knowledge (acquired during evaluation activities) not paying too much attention to student's preferences.

2.1. Personalization based on e-learning styles

Learning is a cognitive activity that differs from student to student. Analyzing adaptability in e-learning system has explicitly pointed out the importance of the modeling learners' cognitive characteristics, particularly, learning styles as the most explored cognitive features. Learning styles are used to specify how learners perceive, process and interact with learning environment. There are several different learning style models presented in literature; however, Felder-Silverman Learning Styles Model (FSLSM) [7] is often used for providing adaptability regarding learning styles in e-learning environments. Felder-Silverman model describes single student in accordance to four dimensinons [7]:

- Active and reflexive learning style
- Sensitive and intuitive learning style
- Visual and verbal learning style
- Sequential and global learning style

To build the initial model, the system's authors must firstly establish the rules [8] to match learning styles with the resource's characteristics in order to determine which resources are more appropriate to a particular learning style. In table1 relations between different learning styles and activities in Moodle[1] learning management system are shown.

[1] Moodle is one of the most used web-oriented LMS. More information on http://www.moodle.org

	Active	Reflexive	Visual	Verbal	Sequential	Global	Sensitive	Intuitive
Forum	Concrete problems	Topics for thinking	No	Yes	Yes	Global topics	Facts, examples	Abstract topics
Chat	Yes	No	No	Yes	Frequent	No	Yes	No
Glossary	Many terms	Concepts	No	Yes	Yes	No	Yes	No
Work-shop	Experiment	Unexplored topics	Yes	Yes	Yes	Yes	Practical examples	Unexplored topics
Survey	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Choice	Yes	Yes	Yes	Yes	Yes	Rarely	Yes	No
Lesson	Problems examples	Provided topics	Illustration	Written, multimedia	Yes	Rarely	Facts, algorithm	Rarely
Comm.	Face-to-face	E-mail	Combined	Combined	Combined	Combined	Combined	Combined

Table 1. Moodle suitability for adaptation

3. Creating personalized e-education system

In order to improve process of personalization in e-learning systems and make it more effective, it would be very useful to identify main steps and requirements.

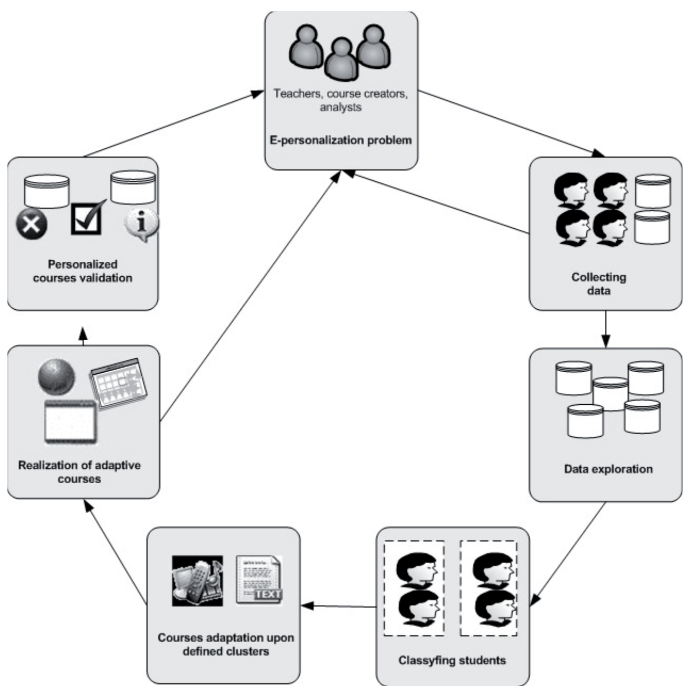

Figure 2. Phases in developing personalized e-education systems

Steps [5] shown in figure 2 shouldn't be realized separately, but as integrated components of iterative and dynamic process of using business intelligence in e-education. In this paper phases 1 - 5 are studied and explained. Research presents strong basis for further optimizing of the whole e-education system.

3.1. Research goals

Primary goal of this research was to implement an adaptive e-learning system. The substantial part of the research was realized through separating students, who attend our e-learning courses, into different clusters according to their learning styles. In the beginning it is necessary to define key segments and models[2] in our adaptive hypermedia system [1]:

- Learner model - collecting personal data (age, sex, etc.), data related to learning styles, as well as relations with domain and context model (year of study, average mark, level of knowledge from similar areas, using Moodle, etc.);
- Domain model - three exams (internet technologies, computer simulation and e-business) on the fourth year of undergraduate studies on our faculty are completely realized through these courses. In addition, we use a concept of blended learning to carry out whole process of teaching [6];
- Content model - refers to all content objects in scope of the courses;
- Adaptation model - this is the position where data mining has key role. Namely, by using intelligent analyses, it is feasible to connect particular concepts and content with student characteristics (i.e. learning styles);
- Instruction model – set of activities that should be performed based on information realized from developed data mining model.

3.2. Collecting data about students

Data were provided by testing sample of 200 students of undergraduate studies on Faculty of Organizational Sciences, Belgrade. E-learning courses include following areas: Internet technologies, E-business and Computer simulation. In addition, we use a concept of blended learning to carry out whole process of teaching. Moodle LMS has being used for creating and organizing these courses.

Due to restraints, which appeared in the process of personalization, not only within the scope of the courses, but also within distance education system, the questionnaire was created in according to FSLSM. In purpose of coordinating and supporting this uneasiness with personalization problem, it was decided to create questions in such way that they represent four dimensions of learning styles. This was the most adequate model for adapting personalization to specific conditions. Survey consisted of 30 questions that dealt with some general topics (average grade, year of study) and the others were about motivation for learning, preferred style of communication, way of presenting content, organizing available time, team working.

In order to obtain more objective data about students' learning styles, we organized introductory course with all types of activities, resources and materials. Course was organized without any kind of adaptation. In order to complete the course, students had to pass a test that was constructed to evaluate knowledge acquired from different types of materials and activities. Test results were to be used for discovering learning styles of students.

3.3. Data exploration

All data collected in two described methods were integrated in single Excel table in such way that each question from questionnaire and from test represented one column. Rows were represented through sets of single student's answers. Although denormalized, this table was suitable for further analysis and data mining. After integration, data were transformed and reduced. Number of options in answers were transformed and reduced to three, and missing data were changed with mean values.

[2] Components are defined according to the proposed architecture in Figure 1.

3.4. Classifying students

Due to the vast quantities of data these systems can generate daily, it is very difficult to analyze this data manually. A very promising approach towards this analysis objective is the use of data mining techniques. Data mining is defined as the nontrivial extraction of implicit, previously unknown, and potentially useful information from large data sets or databases. Therefore, role of data mining as adaptive mechanism in e-learning systems is obvious [10].

Data mining tools and techniques should be situated in adaptive layer in suggested architecture of an adaptive e-learning system. Actually, data mining is used both as a mean for predicting unknown or future values of the attributes of interest, using other existing attributes and correlations, and secondly, to describe embedded patterns, which should contribute to generating the best possible personalized e-learning models [14].

Although personalized recommendation approaches that use data mining techniques are first proposed and applied in e-commerce for product purchase, there are also several works [13] about the application of different data mining techniques within recommender systems in E-learning. Some questions were made in order to lead process of creating data mining structures in right way:

- *What number of clusters is the most appropriate?*
- *What are main characteristics within clusters and differences between them?*
- *Which input variable, i.e. learning style, has dominant influence on grouping of the students?*
- *Is created mining model convenient for further forecast?*
- *Which content should be delivered to students from single clusters?*

3.4.1. Creating data mining model

Clustering, as a data mining technique, was applied in building data mining model. Clustering algorithm finds natural groupings among data related to sets of input attributes, so that attributes inside one group (cluster) have fairly the same values, but among groups (clusters) notable differences exist [15]. It could be asserted that essential aim of clustering is discovering hidden values and variables, which precisely arrange data.

By processing and mining available data it was identified that results were almost of the same accuracy, regardless whether students were divided into two or three clusters, what is explained later in the paper. However, in second case, outcomes were more consistent, logical and of higher quality. Therefore, outputs and conclusions related to the case of three groups will be presented here.

Cluster Discrimination gives possibility to do detailed analysis of key differences among clusters. This is part of clustering algorithm that has the most important role in the whole process of students' segmentation. Table 2 shows differences between clusters 1 and 2. Similar report can be created for analyzing differencing between each two clusters. For instance, a student who prefers professors to specify topics for essays, as indicated in first row of table 2, by agree in the Values column, is more likely to be arranged in Cluster 2 (100%), and a student for whom multimedia materials are the most motivating, is more likely to be grouped into Cluster 1 (58%).

Variables	Values	Favors Cluster 1	Favors Cluster 2
Professors specify issues for essays	disagree		100%
Type of presentation	written materials		69%
Professors determine deadlines	disagree		64%
Type of presentation	multimedia	58%	
Professors specify issues for essays	agree	45%	
Communication method	combined	43%	

Table 2. Discrimination scores for clusters 1 and 2

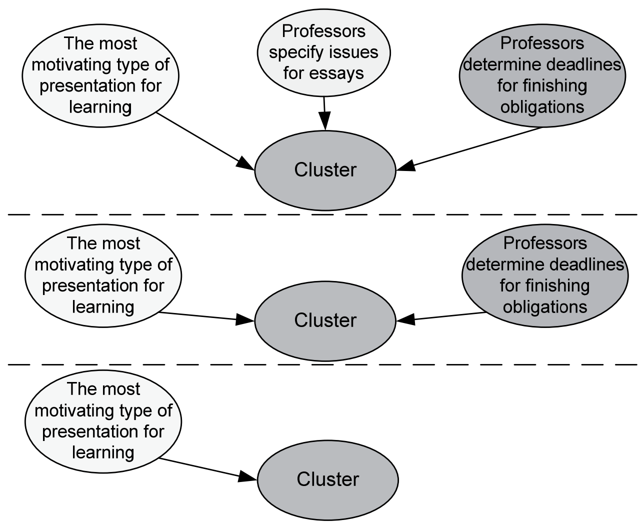

Figure 3. Dependency network

Figure 3 shows that aptitude about the presentation of teaching materials is of the highest importance for students' classification. Also, it is important who determines topics for essays and deadline for finishing exam obligations, professors or students themselves.

3.4.2. Model validation

After data mining model is created, it is necessary to validate it. The method of comparison used here is called mining accuracy lift chart [15]. Results are sorted and plotted in the graph together with ideal model, which presents theoretical model with accuracy of 100%.

If the state of the predictable column, i.e. forecasted class in this case, is specified, than the quality of model could be analyzed. The X-axis of the chart represents percentage of the test dataset that is used to compare the predictions. The Y-axis of the chart represents percentage of values that are predicted to be in specified state, i.e. Cluster 1. The most important thing is that it is significantly above the blue line in the chart, which represents "random guess line". Green line, which indicates the "ideal model", shows that it would "catch" 100% of predicted population (Cluster 1) by using about 50% percentage of available data in the model with three classes. Classifying model would catch 100% of students arranged in Cluster 1 by using approximatelly 80% of total data.

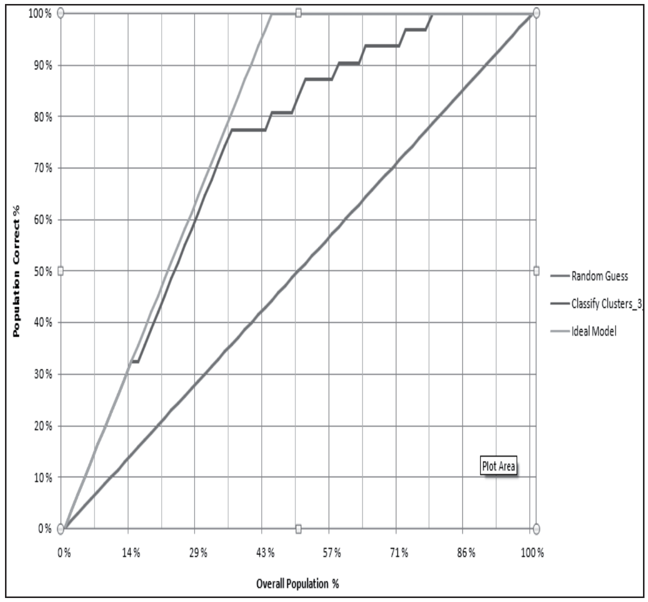

Figure 4 Lift chart for classifying model with three classes for predicting variable Cluster1

3.5. Courses adaptation

Using results of this research changes and adaptations have been made in scope of our e-learning courses. Students have been separated into three groups. There were some similar characteristics for all students, like working in teams or passing exams sequentially. Indicated demands have been fulfilled for all of them by making some possibilities globally available. Although percentages of these characteristics were fairly high in every cluster, this decision could raise question about what happened with students who didn't have same expectation. They were given possibility to choose whether they wanted to use set of global characteristics or to adjust mentioned options by themselves.

According to the fact that main goal was to do some fine-tuning of the courses, final adaptations based on proposed generic model and discussed relationships between learning styles and different types of presentation were reflected in:

- Course level adaptation - students in Group 1 and 2 were let to determine time-limits for finishing exam obligation, but students in Group 3 have been provided with the certain terms for exams.

- Teaching materials - Picture, video, graphs, animation and hypertext materials were delivered to Group 1, but text and audio materials were given to Group 3. Group 2 has been provided with combination of multimedia and written materials.

- Examination - Students in Groups 2 and 3 had projects instead of essays. In Group 1 learners could choose between practical and theoretical tasks. Homework, quizzes and oral exams were obliged for all students.

- Activities - Generally, almost all activities were available for students. The only difference was the way how these activities were organized (Table 3).

			Cluster 1	Cluster 2	Cluster 3
Type of presentation			Multimedia materials	Combined	Text materials
Course activities	Assessment	Choosing topics	Teacher	Student	Teacher
		Type of activity	Project / Case study / Survey	All types	Essay
		Final exam	Test with multimedia questions	No	Oral examination
		Deadline	Strictly specified by teacher	Not defined	Strictly specified by teacher
	Moodle activity		Video lessons, workshops	Wiki, Glossary, Lessons	Text lessons
Communication			Face-to face, Video conference	Forum, chat, Face-to face	Forum, chat, Face-to face

Table 3. Course organization and clusters

In the figures 6 and 7 examples of different type of materials (text and multimedia) are presented.

Figure 5. An example of text materials

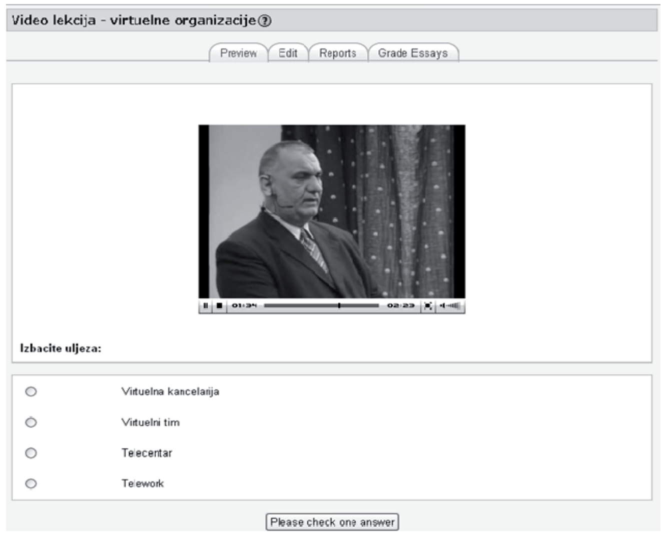

Figure 6. An example of multimedia materials

4. Conclusion

New concepts in academic analytics imply a higher degree of standardization and uniformity in adaptation process and request real time analyzing of collected data. E-learning systems generate an exponentially increasing amount of data, and much of this information has the potential to become new knowledge to improve all instances of e-learning. Data mining processes should enable the extraction of this knowledge. Simultaneously, by following the idea of "eLearning 2.0 [6], e-education systems should fulfill demands for blended learning, open access, connectivity, putting students in the centre.

In this paper the following has been done:

- Generic model and architecture of adaptive e-learning system were proposed
- Main phases and requirements in developing personalized e-education systems were identified
- Data mining model was created upon students' learning styles
- E-learning courses have been adapted

Future research includes activities such as finishing ongoing courses, validation and improving adaptive courses according to new data and providing some more data about students' characteristics. Finally, it would be very useful to develop a real-time feedback loop between intelligent analysis and the adaptive e-learning system.

References

[1] Aroyo, L.; Dolog, P.; Houben, G-J.; Kravcik, M.; Naeve, A.; Nilsson, M.; Wild, F. Interoperability in Personalized Adaptive Learning. *Educational Technology & Society*, 9(2): 4-18, 2006.

[2] Brusilovsky, P. Adaptive hypermedia. *User Modeling and User Adapted Interaction*, 11(1/2): 87-110, 2001.

[3] Brusilovsky, P. Methods and Techniques of Adaptive Hypermedia. *User Modeling and User-Adapted Interaction*, (6): 87-129, 1996.

[4] Derry, S.J.; Potts, M.K. How Tutors Model Students: A Study of Personal Constructs in Adaptive Tutoring. *American Educational Research Journal*, 35(1): 65-99, 1998.

[5] Despotović, M.; Bogdanović, Z.; Barać, D.; Radenković, B. An application of data mining in adaptive web based education system. *WBE 2008*, (610), Innsbruck, Austria, 2008.

[6] Ebner, M. E-Learning 2.0 = e-Learning 1.0 + Web 2.0?. *The Second International Conference on Availability, Reliability and Security ARES'07*, pp. 1235-1239, Austria, 2007.

[7] Felder, R.M.; Silverman, L.K. Learning and Teaching Styles in Engineering Education. *Engineering Education*. 78(7): 674-681.

[8] Graf, S. Fostering Adaptivity in E-Learning Platforms: A Meta-Model Supporting Adaptive Courses. *CELDA 2005*, pp.440-443, Portugal, 2005.

[9] Karampiperis, P.; Sampson, D. Adaptive Learning Resources Sequencing in Educational Hypermedia Systems. *Educational Technology & Society*, 8(4):28-147, 2005.

[10] Koper, R.; Burgos, D. Designing Learning Activities: From Content-based to Context-based Learning Services. *International Journal on Advanced Technology for Learning*, 2(3), 2005.

[11] Paramythis, A.; Loidl-Reisinger, S. Adaptive Learning Environments and e-Learning Standards, *Electronic Journal of e-Learning*. 2(1): 181-194, 2004.

[12] Rashid, A.M.; Albert, I.; Cosley, D.; Lam, S.K.; McNee, S.M.; Konstan, J.A.; Riedl J. Getting to know you: learning new user preferences in recommender systems. *ACM IUI*, 127-134, 2002.

[13] Romero, C.; Ventura, S. (editors), *Data mining in e-learning*. WIT Press, USA, 2006.

[14] Romero, C.; Ventura, S. Educational Data Mining: a Survey from 1995 to 2005. *Expert Systems with Applications*, 33(1): 135-146, 2007.

[15] Tang, Z.; MacLennan, J. *Data mining with SQL server 2005*. Wiley, 2005.

[16] Vassileva, J. A task-centred approach for user modelling in a hypermedia office documentation system, *User Modelling and User-Adapted Interaction,* 6(2-3): 185-223, 1996.

[17] Watson, H.; Wixom, B. The Current State of Business Intelligence. *Computer*, 40(9): 96-99, 2007.