Adaptive courseware design based on learner character

Boyan Bontchev, Dessislava Vassileva

Department of Software Engineering, Sofia University "St. Kl. Ohridski", Sofia, Bulgaria

Key words: *adaptive hypermedia systems, e-learning authoring, learning styles*

Abstract:

During last decade, a great advance has been done in both theoretical research and software construction of Adaptive Hypermedia Systems (AHS). The article discusses the practical approach taken for authoring and instructional design of adaptive courseware based on learner character, namely learner goals and preferences, learner style, and learner performance and satisfaction level. This approach is adopted at pilot test of ADOPTA - adaptive technology-enhanced platform for edutainment. The authoring process relies strongly on an enhanced learning object metadata support, where learning styles are used for adaptive navigation within the narrative storyboard graph. On other side, both learner knowledge and satisfaction level determine adaptive content selection.

1 Introduction

In recent years, the field of adaptive hypermedia systems (AHS) becomes one of the key research e-learning areas. Efforts are focused on tools for creating and managing content that on the one hand can be adapted to various goals, preferences, knowledge and learning style of a learner and, on the other hand, can be reused by various authors and exchanged between different systems. The adaptability to individual learner character may be based on learner's style, performance, goals, preferenceses and so on [1,2]. In many approaches [3,4,5,6], it makes use of clean separation of the learner model from the content model and from the adaptation model, without narrative or pedagogical model to be embedded in the authored content or the adaptation engine. The paper describes adaptive e-learning courseware construction using ADOPTA (ADaptive technOlogy-enhanced Platform for eduTAinment) [7]. ADOPTA has been under development at Sofia University, Bulgaria, since 2007 and already provides prototypes of authoring and instructor tools for e-learning courseware design, plus an adaptation engine being currently under development and executing rules controlling the adaptation process toward the learner model. The adaptability itself consists in delivering different learning content to students with different both learning styles and shown performance as assessment results. The adaptable courseware delivery uses techniques such as adaptive navigation and adaptive content selection [8], based respectively on learning style variation and on assessment results gained via automatically built assessment tests at the control points within the storyboard.

The goal of the further explaination is to describe authoring courseware materials and using them for construction of adaptive courses by the instructor tool and, finally, playing these courses controlled by the adaptation control engine under varios parametrizations.

2 AHS conceptual model of ADOPTA

The construction of adaptive e-learning courseware using the authoring tool is based on a specific adaptability model of AHS which improves the AHAM reference model [5]. This conceptual model has a structure as shown in figure 1 as a mind map. At first level it is divided into three independent from one another sub-models – learner model, adaptation model and domain model. At second level each of these sub-models again is divided into three others sub-models. Thus, the learner model contains information for the learner profile. Depending on its meaning, it is stored in Goals and Preferences, Learning Style or Knowledge and Performance sub-models. It adds support of different learning styles such as Honey and Mumford ones [9], which subsumes activist, theorist, pragmatist and reflector categories of learners.

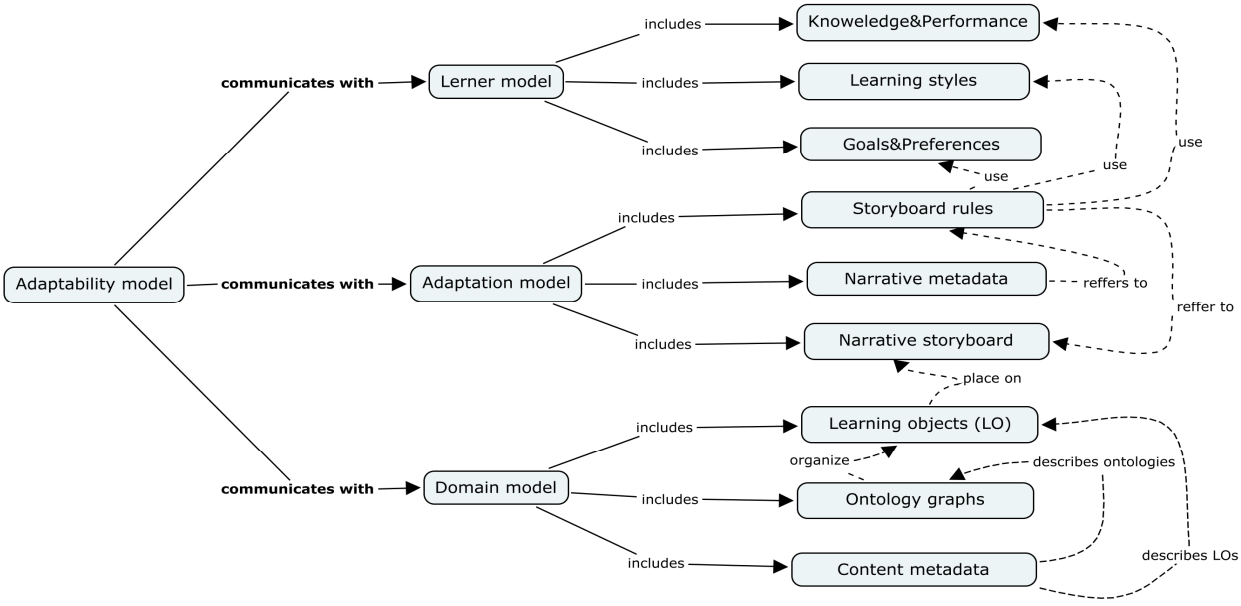

Fig. 1: A mind map of the conceptual model

The domain model is responsible for structuring of learning content. The content is granulized in learning objects (LOs), which are interconnected in relevant knowledge domain ontology expressed in OWL [10]. LOs and ontology are described by their metadata (in Content Metadata sub-model) respectively according IEEE LOM specification [11] and Ontology Metadata Vocabulary OMV proposal [12].

Finally, the adaptation model provides description of each course storyboard graph (in Narrative Storyboard sub-model), metadata (such as link annotations, exam thresholds, etc.) of each narrative storyboard graph (in Narrative Metadata sub-model) and selection logic for passing over particular graph (in Storyboard Rules sub-model). A storyboard graph consists of narrative pages (with learning content compound of LOs), control points (CPs) and so called work paths (WPs) between them (i.e., interconnecting CPs). The instructor may define a weight of a WP for each learning style. Note, that learning character may have a mix of styles and is evaluated by a pre-test in the very beginning of the e-learning process. Therefore, a particular working path (WP) may be suitable for one or several learning styles as designed by the instructor using the instructor tool. The control points are used for assessment of current knowledge and performance for a learner, by test generation. This test is composes of questions corresponding to the LOs in the pages, which the learner is visited. The obtained assessment result is used for update of WP weights.

3 Stages in adaptive courseware design and delivery

The principal workflow used at the platform is presented in the figure 2. There are shown the five main roles: author, instructor, supervisor of the adaptation engine, learner and platform administrator. Their chief responsibilities are as follows:

1. During the authoring process, the author granulizes learning content into learning objects (LOs) such as normal narrative contents, tasks or test questions. LOs are organized in semantic ontology graphs for each domain. Ontology graphs have two types of links - *is_a* for relationship between narrative contents themselves and *has_a* for relationship between tasks and questions and narrative contents. Metadata for ontology graphs and LOs are stored in the content metadata sub-model and are used by the instructor when designing the narrative storyboard.
2. Within the storyboard course graph design, the instructor allocates LOs at the pages of the storyboard graph using LOM to select learning materials proper for the dominating learning styles, and sets page metadata in order to be used by the adaptation engine. For each LO, the instructor defines coefficient of knowledge level, which will be used for adaptive content selection depending on learner performance shown at the last control page. Both the instructor and the learner are able to view the content page shown by a XSL transformation. For control pages (CPs), the content will be automatically generated by a selection of question learning objects referred by objects placed at pages visited by the learner. However, here the instructor has to specify a performance threshold used the adaptation engine for deciding to let him/her to go ahead or to be returned back to the previous CP. Moreover, the instructor may set annotations for the outgoing links to other pages which are used by the adaptation engine for adaptive navigation.
3. The engine itself evaluates learner performance and satisfaction at the control pages and, thus, controls the adaptive navigation through the storyboard and content selection at each page visited by the learner. There are some parameters controlling the adaptive navigation and adaptive content selection which are to be set by the supervisor (fig. 2). Thus, different learners obtains different learning materials best suited to their specific learning styles and shown assessment results.

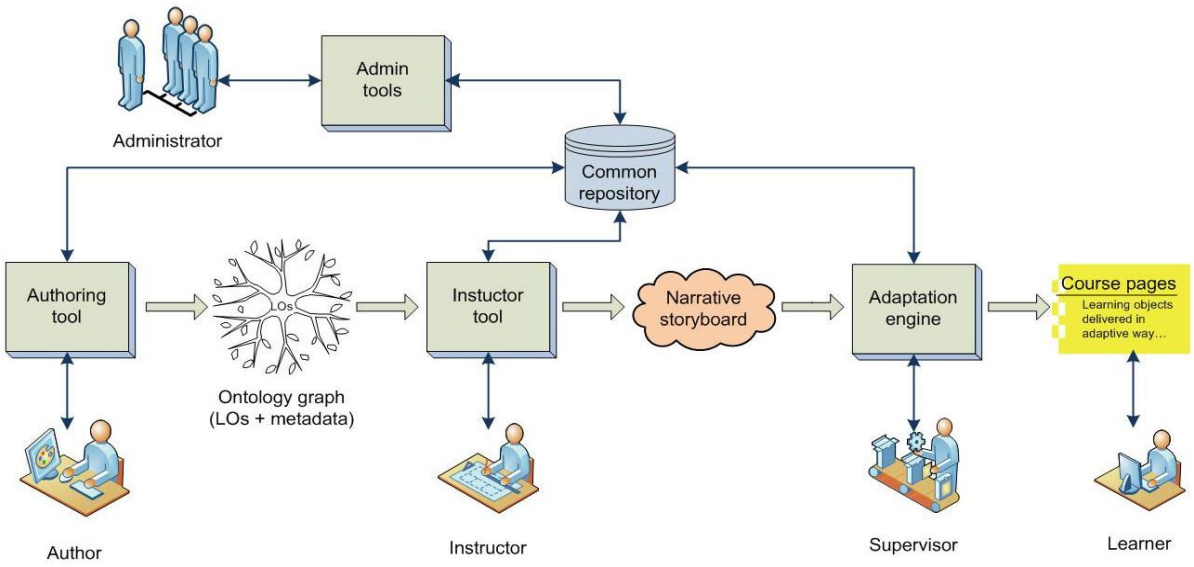

Fig. 2: Principal workflow of adaptive courseware design and delivery

Thus, the workflow comprises three main stages in adaptive courseware design as shown in fig. 3: authoring of courseware LOs, instructional design of an adaptive course and, finally, adaptive courseware delivery in various ways using different delivery parameters used by the engine controlling adaptation. As each of the phases provides results for the next one, it is crucial to plan the work of authors, instructors and supervisors in a coherent way. This means authors should designed many domain LOs of various types suitable for any of the learning styles in order to provide instructors with e-learning courseware material sufficient to construct various working paths for different styles. On other hand, instructors should set proper metadata and parameters for the course pages in order to facilitate a courseware delivery with an effective adaptation towards learning styles and assessment results and promised by the model. As far as this is very difficult to be obtained in an a la waterfall working process, transitions from each one of the phases to one of the previous phases will be quite possible.

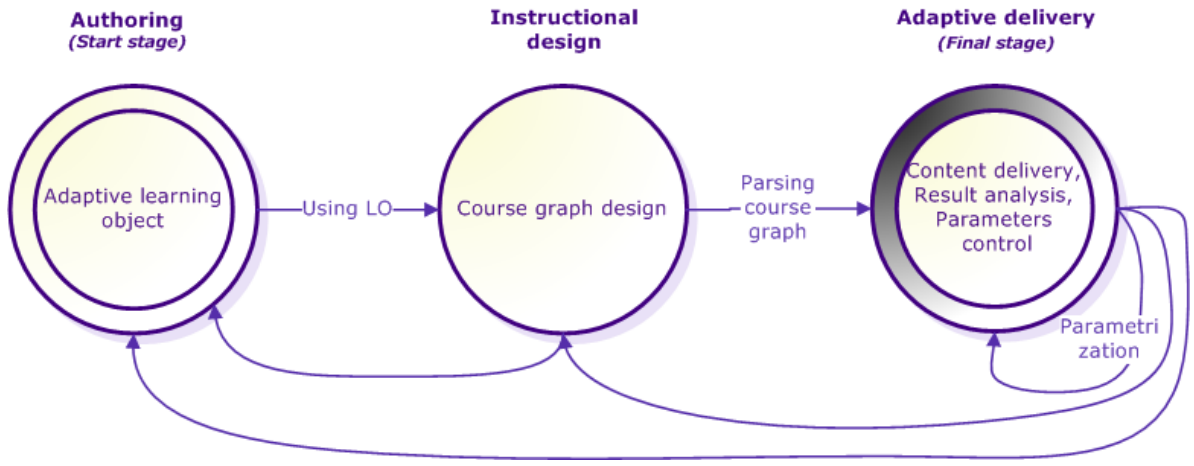

Fig. 3: The three stages in adaptive courseware design and delivery

3.1 Authoring e-learning materials

As stated above, the LOs domain authors are supposed to designed sufficient number of LOs of various types such as formal theory, informal LOs, examples, tasks, essays, quizzes, etc. They have to do that in order to provide instructors with e-learning courseware material to construct various working paths for different learning styles.

Fig. 4 presents a distribution of LOs types according theis suitability for learning styles. They are spread over a two dimentional space formed by the four learning styles according Honey and Mumford ones [9]. As far as activist is complimentary style to theorist and pragmatist - to reflector, it is practical to dispose these two couples on the two axes. Types of learning objects are situated over the axes or between them depending on their suitability for a learning style or for a combination of two learning styles. Of course, a learning character could include any of these four styles (in equal or different aspects) – if so, various types of LOs could be given to such a learner (suitable for any of the styles presented in his/her character).

The distribution shown in fig. 4 is obtained by our practical experience and does not preted to be punctual neither valideated according instructional theory – here we would like just to stress the attention over typisation of LOs produced during the authoring phase and used by instructors in order to place them on different working paths within the narrative storyboard graph

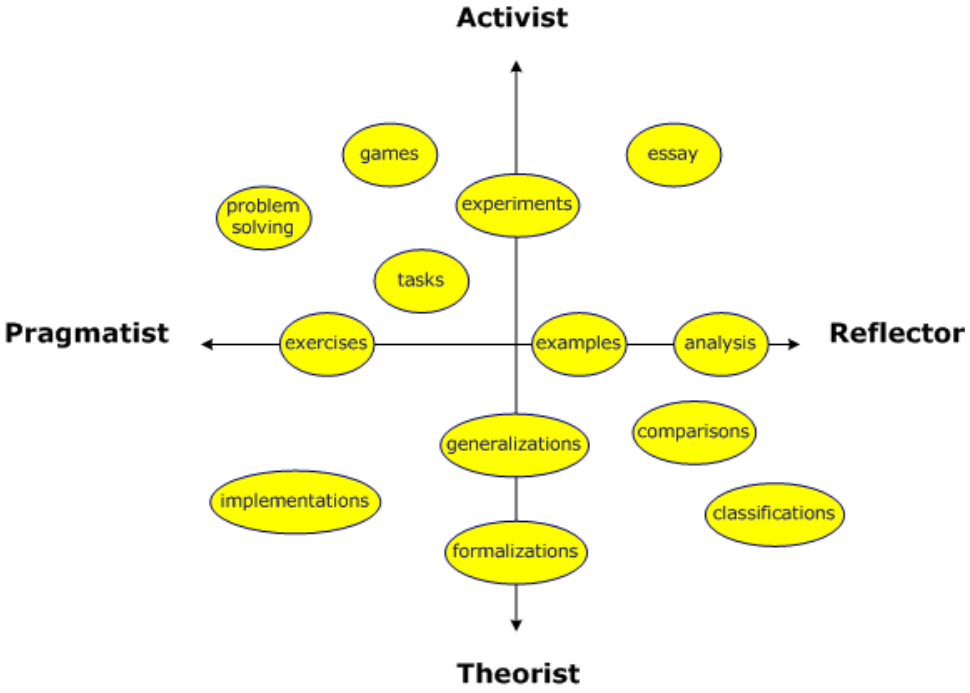

Fig. 4: Distribution of LOs types according theis suitability for learning styles

3.2 Course graph design

In the course storyboard design process, there must be taken into account the following circumstances:

- Every WP from a CP to another one, has to cover the same learning domain part but presented in different ways and corresponding to different pedagogical strategies
- Each course has to finish with a CP. This CP is special, because of the adaptive engine generates final test at it.
- For each combination of WPs, the instructor has to set WP weights for each learning style
- Each link between two pages has to be annotated in the most suitable way
- The cycles in course storyboard graph are not allowed and every WPs must reach a CP
- Used pedagogical strategies have to be appropriated for each learning styles. In ADOPTA we use Honey and Mumford [7] learning styles, but it can be used another – the conceptual model allows this. There are two main strategies for creating of course storyboard graph shown in fig. 5 and fig. 6. In the first of them (fig. 5), we have pages which are mandatory (such as *Page 7* and *Page 6*) for each one student regardless of his/her learning characters. Moreover in this instructional strategy there are many combinations of WPs and two or more WPs can contain the same page. This pedagogical approach is suitable when the group of students for given course have very different learning characters and it is necessary to create WPs with maximum coverage of the coordinate system of Honey and Mumford learning styles. In the second of proposed main pedagogical strategies, the course storyboard graph has parallel structure (fig. 6). Thus instructional design is appropriate for students with pronounced learning style. For example students, who can be determined mainly as theorists, will receive content materials only for this learning style such as formalizations, generalizations, etc.

- The instructor can parameterize the level of difficulty of a particular learning object. This parameter provides information to the adaptive engine whether or not to show a given learning object to a particular student with shown knowledge level.

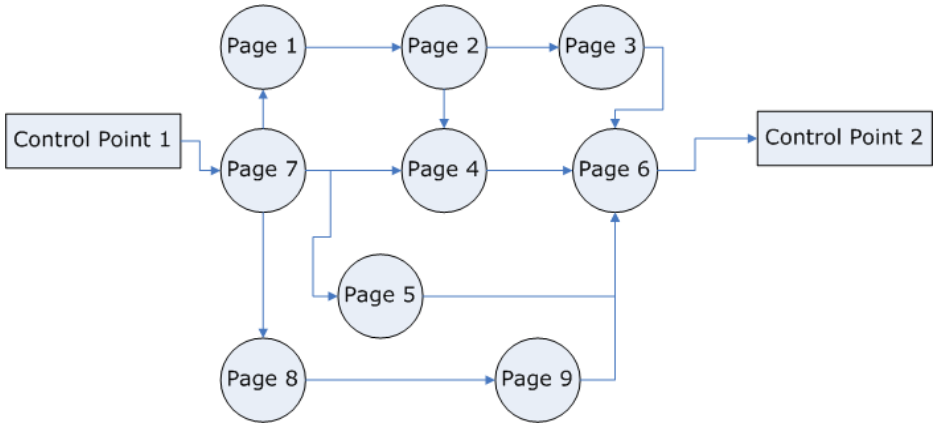

Fig. 5: Sample for strongly connected storyboard graph

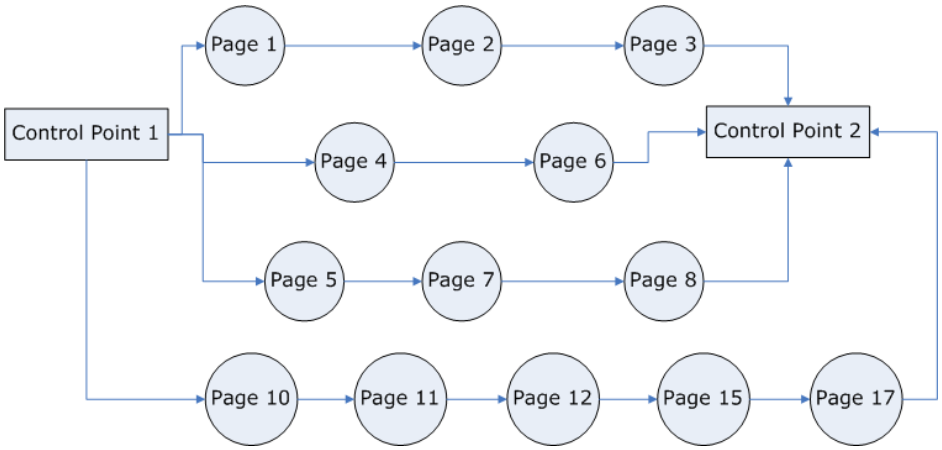

Fig. 6: Sample for parallel storyboard graph

3.3 Adaptive content delivery

The main function of the engine controlling adaptability is to deliver adapted courseware content. Adaptation takes place on two levels - the adaptive content and adaptive navigation, within two main workflows [7]:

- Workflow for adapting the content - through the administration module it is possible to be configured start/stop of content adaptation or of navigation adaptation, how many questions to generate on a CP, and which LOs to be visible at a given page for learner with given assessment results. Fig. 7 presents a screenshot of the administration system for configuring adaptability of content selection based on assessment rank achieved at previous CP. As well, supervisors can use the module for monitoring to track the effectiveness of adaptation.
- Workflow for adapting navigation – with two parts as follows:
    - Workflow at the beginning of a new WP – here the engine chooses the path of greatest weight (computed by the engine itself). The page to be visited is processed so that only the appropriate learning objects to be displayed and, as well, to include suitably annotated link to the next page within the path [13] (although other links are possible, too);

- Workflow at the end of the current WP - involves updating the weights of the traversed path and determining whether the student can continue forward or to return to the start of the path. Updating the weight allows the system to adapt to the profiles of students and ensure the correct choice of the best working path.

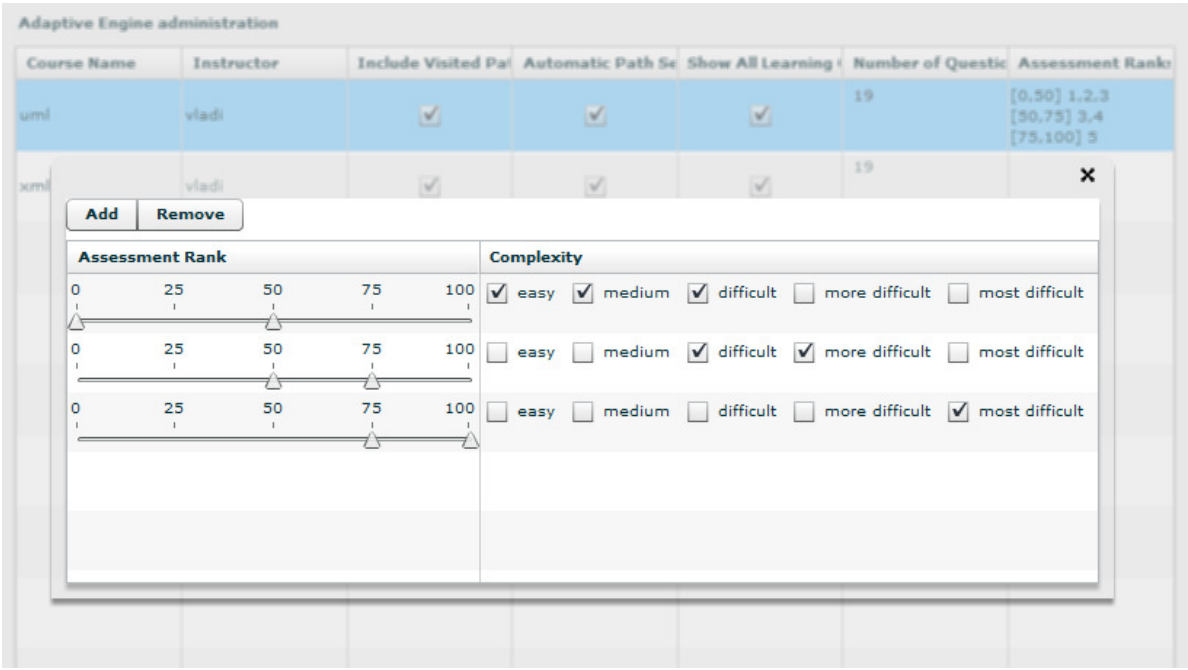

Fig. 7: Administration system – configuration of adaptability of content selection

4 Conclusions

The paper presented a practical approach for adaptive courseware design and delivery based on learner character issues. Moreover, it explained how the adaptation process is controlled via special engine and how the e-learning content delivery can be parameterized. The proposed approach is used in the ADOPTA platform for adaptive edutainment [13]. The processes of content authoring and course storyboard design are separated in order to allow development of a flexible and effective modular software application. The most of described principles can be used also in another adaptive system for e-learning. The proposed approach for adaptive content delivery can be useful for authors of e-learning content and instructors of courses, without any restriction of usage of learning styles families.

Currently, we prepare practical tests for using the integrated ADOPTA platform. For monitoring the effectiveness of the adaptability achieved, we are going to measure the assessment results and learner satisfaction level. One of the issues for future improvement of the platform is addition of module for monitoring of student behaviour. Our plan for betterment of our system more includes adding of artificial intelligence algorithm and neural network in the implementation of adaptive engine.

References:

[1] P. Brusilovsky, J. Eklund, InterBook: an Adaptive Tutoring System,. UniServe Science News, Volume 12, March, 1999.
[2] Esmahi, L. at al. An Essay in E-learning Tools Categorization, Proc. of "Computers and Advanced Technology in Education", Cancun, Mexico, 2002, pp.355-218.

[3] Díaz, P., Sicilia, M.A. and Aedo, I. Evaluation of Hypermedia Educational Systems: Criteria and Imperfect Measures. Proc. of the Int. Conf. on Computers in Education, USA, 2002, pp. 621-626.
[4] Dagger, D., Wade, V. & Conlan, O., Personalization for All: Making Adaptive Course Composition Easy. Special issue of the Educational Technology and Society journal, IEEE IFETS, 2005.
[5] De Bra P. at al. AHAM: A Dexter-based Reference Model for adaptive Hypermedia. Proc. of the ACM Conference on Hypertext and Hypermedia, 1999, pp. 147-156.
[6] Vassileva D., Bontchev B. Self adaptive hypermedia navigation based on learner model characters, Proc. of IADAT-e2006, Barcelona, Spain, 2006, pp.46-52.
[7] Bontchev, B. at al. Architectural Design of a Software Engine for Adaptation Control in the ADOPTA E-learning Platform, Int. Conf. on Computer Systems and Technologies - CompSysTech'09, Rousse, Bulgaria (best paper award).
[8] Vassileva, D., Bontchev, B. and Grigorov, S., Mastering Adaptive Hypermedia Courseware, Acta Electotechnica et Informatica, Vol. 9, No. 1, 2009, pp.57-62.
[9] Guin-Duclosson, N. et al., 2002. The AMBRE ILE: How to Use Case-Based Reasoning to Teach Methods, Lecture Notes in Computer Science, ISBN 978-3-540-43750-5 , Volume 2363/2002, pp. 782-791.
[10] Moreira D., M. Musen. OBO to OWL: a protege OWL tab to read/save OBO ontologies, In Bioinformatics, Vol. 23, No. 14, 2007, pp. 1868-1870.
[11] Krull, G. An investigation of the development and adoption of educational metadata standards for the widespread use of learning objects, Master Thesis, Rhodes University, November 2004.
[12] Hartmann, J. et al. Ontology Metadata Vocabulary and Applications. Proc. of Int. Conf. on Ontologies, Databases and Applications of Semantics, Workshop on Web Semantics (SWWS), Springer, October 2005, pp.906-915.
[13] Vassileva D., Bontchev B.: Adaptation engine construction based on formal rules, Proc. of CSEDU 2009, ISBN 978-989-8111-82-1, Vol.1, Lisbon, Portugal, March 23-26, 2009, pp.327-332.

Authors:

Boyan Bontchev, Assoc. Prof., PhD
Dessislava Vassileva, Research Assoc.
Department of Software Engineering, Sofia University "St. Kl. Ohridski"
125 Tzarigradsko shose blv., Bl. 2, Room 214A
Sofia 1113, Bulgaria
{bbontchev, ddessy}@fmi.uni-sofia.bg