

# STORYBOARD DESIGN FOR COURSEWARE ADAPTATION TO LEARNER STYLE AND KNOWLEDGE

Dessislava Vassileva and Boyan Bontchev

*Dep. of Software Engineering, Sofia University St Kliment Ohrodski  
5, J. Bourchier Blv., 1164 Sofia, BULGARIA*

## ABSTRACT

Both learning style and learner knowledge level are two popular and important properties of the learner model used for realization of some of modern adaptive hypermedia systems. Explicit adaptive courseware development goes from design of learning objects for a specific domain to their usage at pages of narrative storyboard graphs using given pedagogical strategy. The present paper deals with adaptation to user styles achieved in by explicit pre-tests determining the style of each individual learner. On other hand, an adaptive approach applies assessment results for selecting next learning path within the storyboard and, as well, for next selection of learning objects according their knowledge level. The storyboard design explores two different practical approaches for graph construction - one using a strongly connected storyboard and other using a storyboard with two main parallel branches. Both the approaches are explained according an instructor methodology for storyboard design and their benefits and drawbacks and compared and analyzed.

## KEYWORDS

Adaptive hypermedia, learning styles, storyboard, ADOPTA

## 1. INTRODUCTION

When developing online courses in line with modern requirements, teachers should not only cover a limited set of knowledge in particular domain but should also present the knowledge in a manner suitable for different types of students. There are various ways of implementation of students typification, for example grouping them according the level of knowledge obtained until the present moment, their interests, goals, ages or, not at last, learning styles. For more groups of students the course is designed, the more individualized is it. Therefore, the course curriculum will be presented in an appropriate way not only to the level of knowledge as within traditional courses but also taking into account some other factors. Courses developed in this way are called adaptive and are subject to adaptive e-learning (Conlan, 2003).

In last decade, there were proposed many methods and tools in adaptable and adaptive hypermedia systems concerning both modeling mechanisms and implementation issues (Chen and Magoulas, 2005). Adaptation techniques as adaptive navigation, content selection and link annotations are controlled by the user model and adaptation rules for providing relevant adaptation to user's preferences, knowledge/performance, goals, learning styles and navigation history (Paramythis and Reisinger, 2003). While some researchers are focused on content adaptation according learner's goals, skill state, and learning history (Grimón et al, 2009) or learners needs (Albert et al, 2010), other approaches concentrate mainly on adaptation to learners learning styles of given style family (Milošević et al, 2007) or in general (Vassileva and Bontchev, 2009). On other side, adaptivity may be achieved either by automatic generation of working (learning) paths for each student, according to his/her user profile or, better, by definition of learning storyboards applying appropriate instructional strategies and methods in a custom (Vassileva, 2010) or standard way (Britain, 2004). Finally, user personalization may be implemented in an adaptive way (adaptive systems use implicit inferences based on user interaction for tailoring the content) or, in contrast, following adaptability rules - by using explicitly provided user input to personalize output (Velsen, 2008).

The authors of present paper have found both learning styles and learner's performance are of key importance for realization of efficient courseware user adaptation (Vassileva et al, 2009a). Within the scope

of ADOPTA (ADaptive technOlogy-enhanced Platform for eduTAinment) project<sup>1</sup>, there is developed a software platform for adaptive content delivery based on adaptivity to learning styles and learners performance (shown knowledge level). In order to facilitate elaboration of storyboard based on different pedagogical strategies, an instructor tool has been developed for enabling instructors to define paths within the storyboard graph most suitable for learners with given learning style. Instructors are free to select any pedagogical strategy covering desired set of criteria and, next, to apply it using various annotated learning objects – imported or designed by ADOPTA authoring tool (Vassileva et al, 2009b), and organized within author ontology. Adaptation to user styles is assured by both explicit learner pre-tests (adaptability) and, as well, by using assessment results for selecting next path within the storyboard (adaptivity). Assessment results are applied also for selecting learning objects (LOs) according their knowledge level.

After a short review of ADOPTA, the paper presents practical experiments with two different approaches for creation storyboards of courses both adaptive and adaptable to learner's style and knowledge level. The platform model sets no limits for using a particular learning styles family however, especially for these experiments, the authors use Honey and Mumford styles (Milošević et al, 2007) as one of the most populated learning style families. The developed storyboards concern a XML technology course taught to undergraduate students at the Faculty of Mathematics and Informatics, Sofia University, Bulgaria. There are analyzed benefits and disadvantages typical for these approaches as well as their suitability for different cases.

## 2. ADOPTA: A BRIEF OVERVIEW

The adaptive content delivery process implemented in ADOPTA is developed in line with contemporary requirements for adaptive e-learning systems and supports interoperability of educational materials and activities, reusability of LOs and construction of e-learning course according to user learning styles and user knowledge level (Velsen, 2008). Since the storyboard graphs are designed using the ADOPTA platform, this section briefly presents the conceptual model and the platform process workflow.

### 2.1 Principal Conceptual Model

The ADOPTA platform is based on a custom conceptual model based mainly on the AHAM reference model (De Bra et al, 1999). The model takes use of several additional elements, as follows:

- support of unlimited number of learning styles – e.g. the style family of Fleming's VAK/VARK model, Honey and Mumford's model or/and Anthony Gregorc's model, etc.;
- support of metadata about LOs, ontologies and adaptation control rules;
- opportunity for export/import of LOs under the SCORM standard (Rey-López et al, 2006).

The ADOPTA conceptual model consists of three main models - Learner model, Adaptation model and Domain model. Each of them includes other three sub-models. These sub-models are responsible for storing different information related to adaptive e-learning process. Thus, each one of the main models is independent on the others. This enables an easy expandability of each one of the models without any need of changing the others.

The Learner model aims to provide different data for student characters, goals, knowledge and results. Respectively, its sub-models are about student's *Goals and preferences*, *Learning styles* and *Knowledge and Performance*. The Adaptation model contains *Narrative storyboard*, *Narrative metadata* and *Storyboard rules* sub-models. These three sub-models present the structure of directed narrative storyboard graphs and their parameters, properties and rules for traversals. Every course is related to a storyboard graph that contains two types of nodes and transition between them. Nodes can be narrative pages and control pages (CPs). Narrative pages include educational content presented by learning objects defined in the Domain model. Control pages are used to assess current knowledge and performance of learners. They consist of test questions, which are automatically generated by the Adaptive engine. These test questions are defined in the Domain model and are associated with one or more LOs. At CPs the Adaptive engine randomly selects predetermined number of these test questions, which are associated with learning objects visited by learners.

<sup>1</sup> ADOPTA project (2008-2011) is funded by the Bulgarian National Science Fund under agreement no. D002/155.

In the course storyboard graph, between two CPs there are some established working (i.e., learning) paths (WPs). Each WP is associated with a weight for each learning style. These weights indicate how a given WP is suitable for a learning style. Implementation of various pedagogical approaches should be consistent with the Adaptation model.

The Domain model and its sub-models - *Ontology graph*, *Learning objects*, and *Content Metadata* are responsible for structuring of educational materials in form of learning objects, organized in ontology, and description of their metadata (both for ontologies and LOs). In ADOPTA platform are used Ontology Metadata Vocabulary (OMV) standard for description of ontology metadata and IEEE LOM specification for description of LOs metadata (Vassileva, 2010).

Another important element of the conceptual model is the Adaptation engine. It is in the core of the model and controls the delivery of most appropriate learning content to the learners.

## 2.2 General Process Workflow

The ADOPTA platform follows the above described model, so its architecture consists of three main modules – authoring tool, instructor tool and adaptation engine that realizes basic ideas respectively the principal conceptual model. Moreover, the ADOPTA platform includes an additional help module – the administrative tool.

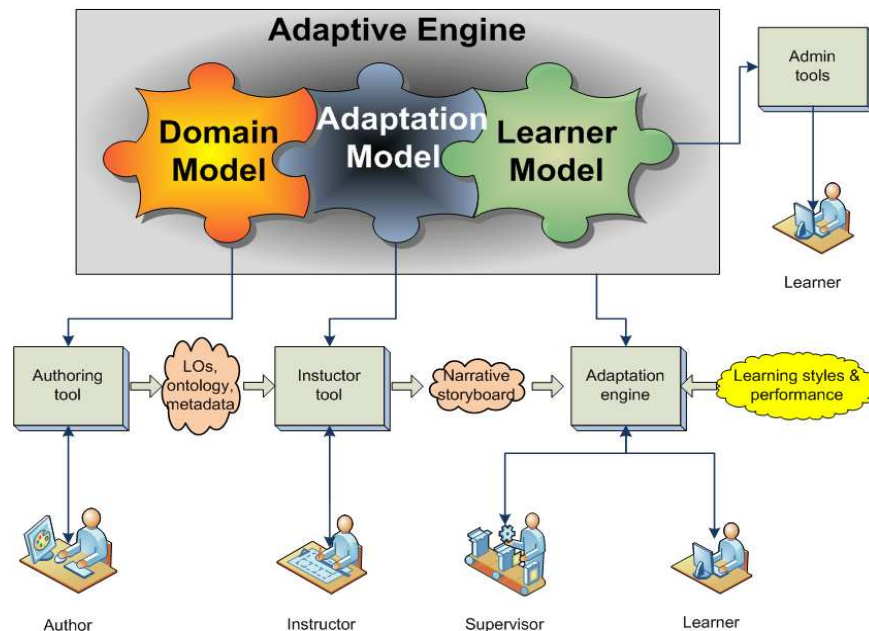


Figure 1. View of the ADOPTA model and platform workflow

Figure 1 shows ADOPTA process workflow and its association with the principal model. Following the Domain model, the author creates LOs by means of the Authoring tool, organizes them in ontology and describes them with metadata. After then the instructor accordance with the Adaptation model uses the Instructor tool to select appropriate LOs, put them in narrative pages, design course storyboard graph as he/she connects narrative pages and set suitable parameters for incorporated in the course pedagogical strategies. The Admin tool enables learners to register in the system and to defined and updated his/her profile (goals, preferences, learning styles).

The learner starts a course by making an initial test about determining his/her learning style. Next, he/she follows a work path proposed by the adaptation engine as a most appropriate path for his/her style or, otherwise, selects another WP (Vassileva and Bontchev, 2009). Knowledge and performance of learners are determined by the Adaptation engine in CPs based on their test results. Along with knowledge and performance, in CPs WPs weights are also updated – if particular learner takes test with good result at a CP, weights of the WP traversed by him/her will increase, unless otherwise.

### 3. APPROACHES FOR ADAPTIVE COURSE CONSTRUCTION

The two approaches for construction of adaptive course storyboards in ADOPTA presented here correspond to the conceptual model of adaptive hypermedia and, as well, to the methodology for constructing adaptive courses given in (Vassileva, 2010). The methodology itself is outlined shortly below.

#### 3.1 Methodology for Adaptive Course Storyboard Design and Management

While designing storyboard graphs via the ADOPTA instructor tool, the instructor is supposed to develop a storyboard graph and to select, group and distribute among the graph pages appropriate LOs according to current knowledge, opportunities and learning style of a particular learner.

At the very beginning of the design process, the instructor is guided only by possible learning styles of students. For this purpose, the storyboard graph has to have a few initial nodes or to start from a node giving basic information and, next, to fork the WPs within the graph. To cover the four learning styles of Honey and Mumford, the storyboard graph must possess at least two WPs in which the pedagogical strategy is directed primarily at two poles of the x-axis or y-axis in fig. 2. As well, each path has to include elements from the other axis, respectively y-axis or x-axis. Practically, a storyboard graph has to include at least one WP for activist and one WP for theorist students, both incorporating LOs for activist and theorist (fig. 2a) or, otherwise, for reflector and pragmatist (fig. 2b).

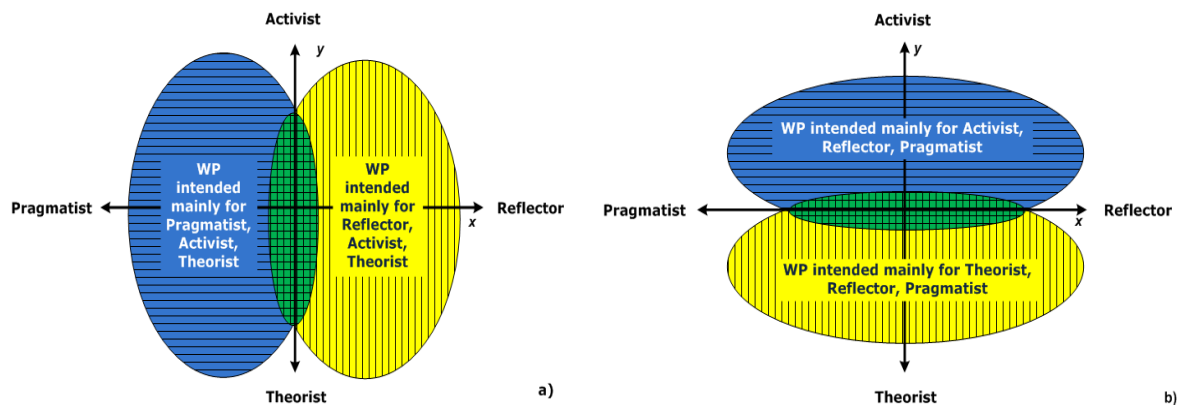


Figure 2. Sample storyboard graph coverage of the four learning styles of Honey and Mumford

After defining the first control point (CP), adaptation of educational content can be completed except for learning styles and level of knowledge gained. Fig. 3 shows two sample student learning styles. Therefore nodes of storyboard graph, i.e. narrative pages can be composed of different difficulty learning objects. The difficulty may be presented in the form of a few levels, e.g. very easy, easy, medium, difficult and very difficult. In such cases, for each of them the instructor must determine in what test result of the learner obtained at a CP, the relevant LO is visible for the learner. The LO will be seen only by students visiting the page with that LO and having test result at the last CP equal or greater than the difficulty level of the LO.

During the storyboard construction process, the instructor may add annotations (such as comments and clarifications) to the links between two pages of the course storyboard graph. They will be seen by the student when transiting from current to next page. If the current page is split to several other pages belonging to different WPs, then the instructor should give a brief description of the contents of the WP and what is directed. Thus, the student is allowed to decide to continue or not via a WP different from that proposed by the system. Therefore, a learner is given freedom to choose the most appropriate path recommended for him/her by the adaptation engine or, otherwise, another available path.

Following the methodology outlined over, there have been constructed two different storyboards for the same learning course concerning XML technologies and languages, taught to undergraduate students at Sofia University.

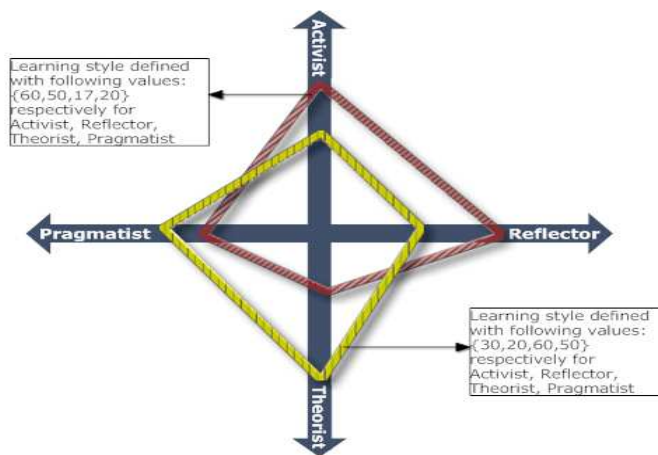


Figure 3. Sample student learning styles

### 3.2 Adaptive Course Construction using a Strongly Connected Storyboard

The design of adaptive courses under this approach uses a strongly connected storyboard as shown in fig. 4. Its narrative storyboard graph begins with two working paths where educational content is intended for activists (in one of the two WPs, which is denoted as *WP1*) and for theorists (the other WP denotes as *WP2*). After the first two pages (denoted as *P01*, *P1* from *WP1* and *P02*, *P2* from *WP2*) of each of the two WPs, they intersect at a common page (*P3*) and then they are divided into two again through two pages for each of them (respectively *P4* and *P5*). This produces four different WPs shown in different line styles in fig. 4 - *WP1* containing pages *P01*, *P1*, *P3*, *P4*, *WP2* containing pages *P02*, *P2*, *P3*, *P5*, *WP3* containing pages *P01*, *P1*, *P3*, *P5* and *WP4* containing pages *P02*, *P2*, *P3*, *P5*. Thus, the newly formed paths *WP3* and *WP4* will combine content both activists and theorists and this would be reflected in the determination of their weights. They will be useful for students, whose learning style is predominantly activist and theorist.

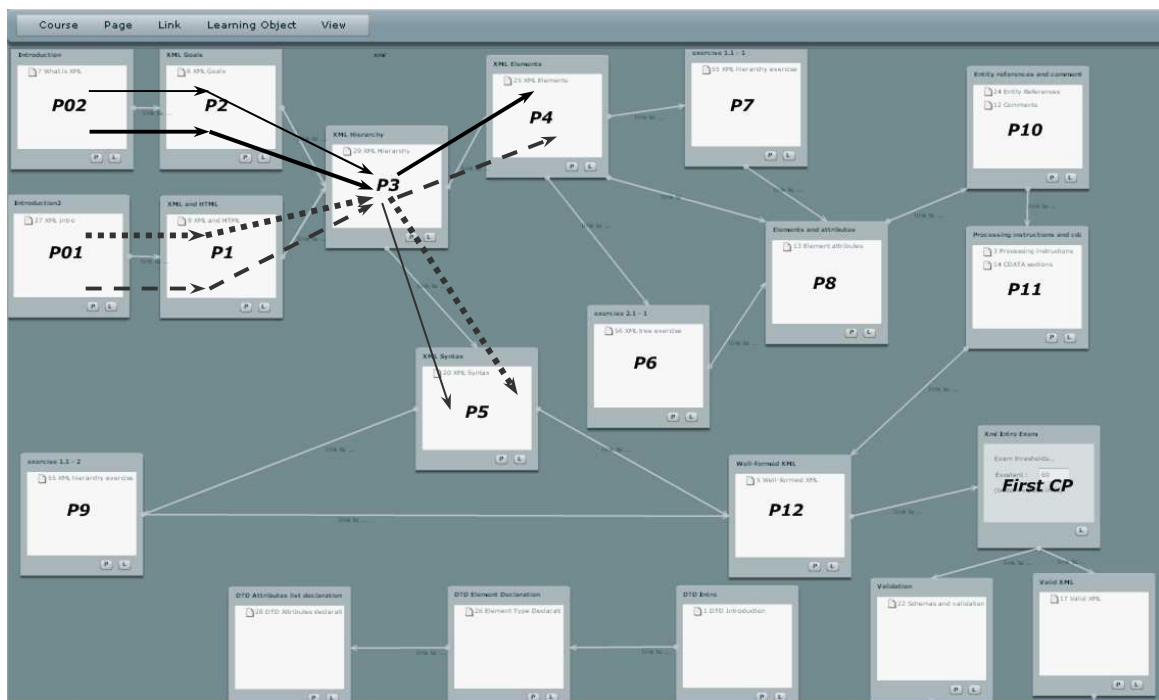


Figure 4. Partial view of a strongly-connected narrative storyboard graph in the ADOPTA instructor tool

The following pages added to the narrative storyboard graph supplement it with educational content within already discovered by the tool WPs (WP1, WP2, WP3, WP4) and add new paths that include learning materials, mostly in the form of tasks and exercises designed to pragmatists and reflectors. Thereby in the storyboard graph they are available different combinations of contents and each of them is best suited for a particular learning style. Until the first control point, we have *eleven different WPs* covering all learning styles of the family of Honey and Mumford.

Educational content to activists contains more examples and it is presented more schematically, unlike materials for theorists where they are given more detailed explanations and formalization. LOs intended for pragmatists are presented by practical tasks and exercises, unlike of these for reflectors that are associated with reporting, analysis and comparisons. After the first control point, in the storyboard graph continues the addition of the WP in a way similar to that described above. Educational content is already consistent except with the learning style of a particular learner and with her/his shown knowledge in control page. This means that there has been added different in complex LOs. The more complex of them are visible only to students with higher test result in the control point but easier for all learners.

### 3.3 Adaptive Course Construction using Parallel Branches

This approach, like the previous one and according to our specific methodology, has two main lines and WPs, which follow them. Educational content in one of them is intended for theorists and in the other for opposite learning style - activists. For example, those students who have a learning style with higher value for activists will be directed of adaptive machine to the corresponding WP.

As shown of the fig. 5, each of the two main WPs in several places is divided symmetrically of two other and then they are merged again. This design produce two sets of WPs as one of them contains all the WPs for activists but the other contains all WPs for theorists. The purpose is to WPs respectively for activist and theorist to be added materials to both pragmatist and reflector. Thus, at some of transitions of the storyboard graph from one page to another students pass through learning objects designed respectively either for pragmatist or for reflector. Usually these learning objects as in the other approach are of type of task.

Whenever one of the main WP (for activist or reflector) is divided into two elements of the relevant set of WPs (for activist or reflector) is increased double. Thus, the number of WPs leading to the first control point is 48. In order to avoid the maintenance and initialization of all WPs weights, we are set only the weights of the two WPs as shown in fig. 5 for the paths starting from page P1- for activist-pragmatist/activist-reflector, and respectively for theorist-pragmatist/theorist-reflector. The weights of the other WPs are not set and, thus, they are initialized with negative values, which prevents theirs usage by the adaptive machine.

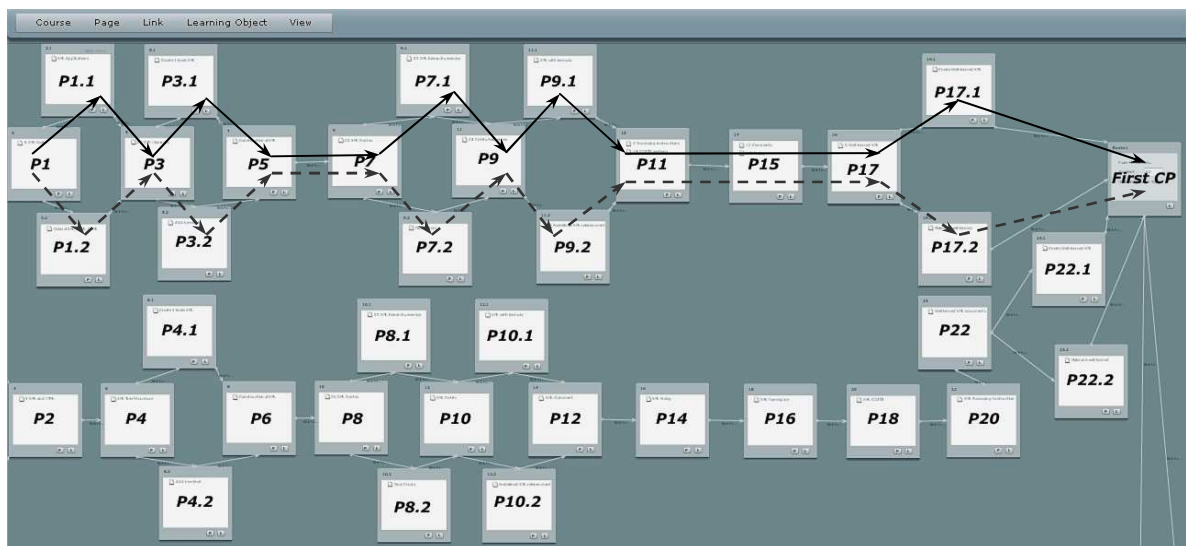


Figure 5. Partial view of a narrative storyboard graph in the ADOPTA instructor tool with two main parallel branches

Thus, in the resulting storyboard graph there are four active WPs - one for each quadrant of the coordinate system of Honey and Mumford. This coverage could be complement if necessary with other WPs, that combines learning pages for three of the four styles of learning.

The above figure presents the storyboard graph from the beginning of the XML course to the first control page. Then course design continues in a analogous way. Educational content shown to a learner depends on his/her results obtained by assessment test at the previous control page. It is divided into three categories according to its complexity:

- easy, which is visible of all learners passed the test,
- medium, which is visible to all learners with a test score above 75%
- difficult, which is designed for learners with a test score above 90%

Thus, classifying educational content enables more bright students to develop their skills and to advance, however, the other learners are able to focus on basic course concepts.

## 4. DISCUSSION

Both the approaches for construction of narrative storyboard graphs for adaptive learning have some benefits and disadvantages. Based on a survey distributed among several instructors having ICT competences, we have identified them as follows.

A. For the approach using a strongly connected storyboard:

- The benefits of such storyboard consist in availability of various WPs within the graph covering fully any dominant learning styles represented in fig. 3. There are met not only the minimum conditions of the methodology to cover this coordinate system in fig.2 but there added other options that enrich the course and make it more customizable to learning styles.
- The drawbacks of this approach are the relatively large number of WPs (greater than 4) which are hardly manageable, since each one instructor must entered weights and then to monitor and analyze the weight changes set by the adaptive engine. This leads to difficult tracking how learning takes place in each of the WPs and, hence, bears the difficulties to the supervisor when monitoring the course.

B. For the approach using a storyboard with two main parallel branches:

- As benefits, the approach provides presence of a relatively small number of main parallel WPs from one CP to another. This makes the storyboard development much easier and facile to maintain, to analyze and to change WP weight and/or included LOs.
- On other side, though the full coverage of the four quadrants for learning styles in fig. 3, this approach has as disadvantage a lack of a greater number of combinations of WP designed different values of learning styles. For example, unlike the first approach, here in case of similar values for activist and theorist learning styles there is no defined WP and the adaption control engine should choose one randomly. Thus, the instructor is not able to interfere in determination of WP for such special cases.

## 5. CONCLUSION

The paper has presented practical approaches for creation storyboards of courses both adaptive and adaptable to learner's style and knowledge level using the ADOPTA platform. While *adaptability* to user styles is achieved on the base by both explicit learner pre-tests, assessment results at each CP determine *adaptive* selection of next WP and knowledge level of LOs shown next to the learner. Each one of the both approaches for adaptive and adaptable storyboard design possesses its own advantages and shortcomings. However, thanks to practicing them in several courses, authors have established that the approach with two main parallel branches is much more practical for design use. Moreover, random selection of appropriate WP for a learner with similar values for two opposite learning styles is not a real problem as far as knowledge level as far it concerns a border case.

The courseware both adaptive and adaptable to learner's both style and knowledge level is used to teach undergraduate students at the Faculty of Mathematics and Informatics by Sofia University. Though initial feedback from learner it quite positive and motivating for next experiments in the area, after finishing the course learners' attitude will be evaluated by filling special surveys. Results will be analyzed in order to determine the benefits and advantages of the current platform prototype and, thus, to reveal ideas for future improvements of ADOPTA.

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