Learning Objects Types Dependability on Styles of Learning

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Abstract: - Theory of learning styles is steadily evolving in several decades and reveals importance of such styles for construction and adoption of adaptive e-learning platforms. Courseware delivery adaptive to learning styles needs precise definition of types of learning objects most appropriate for individual given learning character with its specific learning style. The present article provides results of a case study of courseware delivery of various types of learning objects such tasks, projects, essays, games and intermediate tests with adaption based on learning styles. It presents evaluation of dependability of learning object types on the styles of learning defined by Honey and Mumford and shows how practical results may differ from expected ones for some of the cases.

Key-Words: - Adaptive, Learning Styles, Learning Objects, ADOPTA

1 Introduction
The efforts of modern e-learning systems have been mainly focused on increasing its efficiency both in the context of delivery of learning materials and in the context of developing the educational content. These efforts have established the several of contemporary trends in the creation and design of learning materials, namely as they are following:

- the content provided to the user to be consistent with his/her profile (known as learner model or user model);
- educational content of a course to be created in a way allowing its reuse in another course and context, and import/export to another e-learning system;
- training materials to be organized so as to enable import / export of the whole course with the pedagogical strategy used in it.

Adaptive hypermedia systems (AHS) are most commonly used to implement the above requirements. According to Brusilovsky [1], AHS is any system that uses hypertext and/or hypermedia, which focuses on the user and implement its user model to adapt various aspects of the system to him/her. This type of systems is most wide application in the e-learning area.

There are different reference models of AHS, which implement the above conditions in different level. Some of them are: Dexter Hypertext Reference Model [2], AHAM Reference model [3], Goldsmiths Adaptive Hypermedia Model (GAHM) [4] and the triangular conceptual model (TCM) [5].

These advantages of TCM are as follows:

- availability of content metadata and adaptation rules;
- packaging of content to the standard IEEE Learning Object Metadata (LOM) [7] and OMV [8];
- TCM consists of three sub-models – the learner model, the domain model and the adaptation model, which are completely independent of each other.

These additional features make the learning process more efficient and provide opportunities for more reliable interoperability, which entirely satisfies modern requirements to create, design and delivery of learning content.

This article will present results of a study examining the preferences of students to the types of educational content (narrative content, assignments, essays, serious games, etc.), according to their learning style. The study was conducted with the platform ADOPTA (ADaptive technOlogy-enhanced
Platform for eduTAinment), implemented in accordance to the TCM. It involved 42 students of the Faculty of Mathematics and Informatics at Sofia University, Bulgaria.

The next section of the article makes a brief introduction to the concept of creating educational content in the form of learning objects and examine different models of learning styles. The rest of paper describes the experiment and analyzes the obtained results.

2 Background

2.1 Learning Objects

Learning objects present a new paradigm for creating teaching materials. In the old paradigm the training is organized into lessons and courses that implement predetermined objectives of the course or lesson. In the new paradigm educational content is divided into smaller independent units that can be used both separately and combined (static or dynamic) with other ones ([9], [10]).

Main properties that a learning object needs to have are modularity, interoperability, opportunity for reuse and accessibility. For the purpose each learning object has to be described by metadata that provide information about its context, characteristics, intended and features. The use of metadata improves and simplifies the extraction of information. Moreover, they could support interoperability, integration of a learning object and its identification. The most popular and widely used standards for metadata in the e-learning are two - Dublin Core [11] and IEEE LOM [12].

Learning objects can contain text, video, audio, graphics, and other learning objects. According to the objective of the learning activity they could be divided into the following types:

- **narrative content** – it represents real learning content. The content author is supposed to select the appropriate level of learning object’s complexity, which helps the instructor to choose suitable training materials.
- **test question** – it assesses learner knowledge of a set (one or more) of learning object (of type narrative content) or a concept.
- **task** – contains text description of the requirements for a project or a description of the problem that the learner has to solve.
- **topic for essay** – specifies one or several topics for essay, describes the requirements for it, assigned evaluation criteria and guidelines for work.
- **serious game** - keeps students actively engaged in the learning process and assist them in developing and enhancing their skills for critical thinking, collaboration, decision making and problem-solving.

2.2 Learning Styles

Learning style is a combination of intellectual, emotional, psychological, physical and sociological personal characteristics that allow students to absorb, learn and gives meaning knowledge and competences. Researchers ([13], [14]) have established that familiarity of the learning style is essential to improving learner’s performance ([15], [16]).

In recent years there have been developed many learning styles with several variations of them. According some researchers ([17]) for identifying different learning styles, there may be encountered the following four basic types of approaches:

- approaches dealing with personal cognitive characteristics of the type field dependence / independence [18];
- approaches focused on concentration on learning preferences [19];
- approaches dealing with ways of learning and combining elements of cognitive and personal learning preferences - a multidimensional model [20];
- approaches dealing with ways of processing information - based on the cyclical model of Kolb [21] and the styles converger, diverger, accommodator, assimilator and, as well, on the Honey and Mumford [22] model.

For the the present study, there are used established and widespread pedagogical strategies for adaptative training, together the learning styles of the Honey and Mumford [6]. The Honey and Mumford’s model is based on the theory of Kolb [17] according to which the training has two dimensions - perception (y-axis in fig. 2) and processing of information (x axis in fig. 2). Each of these dimensions is bipolar and, thus, four styles can be represented by two-dimensional coordinate system. According to Honey and Mumford the preferred style is dominant but always adds to itself elements of other.
The Honey and Mumford model includes the following four predefined learning styles:

- **activist** – he/she is enthusiastic for new ideas, experiments and seek challenges. Activists prefer to be direct involvement in carrying out a task rather than listening to lectures and detailed descriptions;
- **reflector** – he/she does not proceed to action, preferring to observe a situation from different perspectives and to gather as much information about it. Reflectors like to analyze, to work with examples and detailed plans to accomplish a task, project or problem;
- **theorist** – he/she is the opposite of activist. Theorists are relevant to the research, formalization, concepts and logical theories. Works well with symbols and abstract concepts and fully oriented research;
- **pragmatist** – he/she is opposite the reflector. Challenge for students with such prevailing style is to apply theoretical ideas into practice. Most important for them is to acquire practical competences. Pragmatists are attracted to work on real projects and to deepen the study and analysis of abstract ideas, concepts and theories.

![Diagram of Learning Styles](image)

**Fig. 1: Relationship between learning styles of Kolb and Honey & Mumford**

Fig. 1 represents graphically the relation between learning styles of Kolb and Honey and Mumford found in [23]. The **activist** corresponds to Kolb’s styles of **accommodator** and **divergent** and feeds from concrete experience, while the **theorist** matches **convergent** and **assimilator** and benefits from abstract conceptualization. On the other side, the **pragmatist** corresponds to **accommodator** and **convergent** and adores active experimentation, while the **reflector** matches **divergent** and **assimilators** and relies on reflective observation.

### 2.3 E-Learning with Adaptation to Learning Styles

Distribution of types of learning objects (LOs) according their suitability for Honey and Mumford learning style is presented in [24] and it is shown in fig. 2. This distribution is a result of longstanding practice of paper authors in teaching students. According [24] learning objects of type game, essay, project, problem-solving, comparative analysis and observation task can also be used to assess learners knowledge as well as classic tests. Depending on the extent to which a LO is suitable for a learning style, there may be selected a set of candidates LO for evaluation. LOs for assessment are presented in fig. 2 with ellipses having black labels. Mainly assessment approaches are as follows [24]:

![Diagram of Learning Object Distribution](image)

**Fig. 2: Distribution of learning objects among Honey and Mumford learning styles [24]**

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• **self assessment** – LOs which are suitable for this method are traditional tests and single user games;

• **peer assessment** – LOs of type essay, task observation, multi-user game and comparative analysis tasks are the most appropriate for this approach;

• **teacher assessment** – for this approach, the most suitable types of LOs are comparative analysis, task observation, essay, projects and tests.

### 3 Courseware Delivery with Adaptation to Learning Styles

In order to access an adaptive courseware delivery, instructors have to develop an e-learning course using authored contents and following pedagogical strategies for adaptation to some features of the learner model such as goals, emotions and preferences, skills and performance shown by assessment tests and, as well, learning styles [24]. This chapter of the paper presents a case study of design and delivery of adaptive courseware to bachelor students by using the ADOPTA platform and, next, provides an analysis of obtained results.

#### 3.1 Adaptive Courseware Design in ADOPTA

The ADOPTA platform technology-enhanced learning allows to learning style and assessed knowledge of individual learners and comprises an content authoring tool, an instructor tool and an adaptation control engine [5]. Authors use the authoring tool for creating learning objects (LOs) organized within ontology and for annotating both the LOs and ontology using respectively LOM and OMV. Next, instructors create narrative storyboards of adaptive courses with various paths within the storyboard graph for different learning styles, by specifying for what a style a given path is appropriate. They allocate LOs of different types on a path according their suitability for given learning style as discussed above. Learning styles are assessed in the very beginning of the course by filling a questionnaire. As well, instructors dispose LOs of different difficulty levels on pages of the path, in order to allow the adaptation control engine to select most appropriate LOs for learner performance shown until the moment (adaptive content selection). Each one of the paths finishes at a control page where the engine generates an assessment test using questions about LOs traversed by the individual learner. If the learner passes the threshold defined for the control page, the engine selects the most appropriate for him/her path to the next control page and he/she starts traversing that path (adaptive navigation). Otherwise, the learner fails with the current assessment test and is returned back to the previous control point.

For allowing adaptive courseware delivery, instructors have not only to design the course storyboard using appropriate types of LOs for different learning styles but have also to calibrate the delivery process by specifying weights for all the paths for the learning styles (e.g., for the four styles of Honey and Mumford), thresholds at control pages, complexity levels of LOs for each assessment test, annotations for links outgoing from the path, etc. All these settings are used by the adaptation control engine for management and monitoring the adaptive learning process.

For the evaluation of the adaptive courseware delivery of ADOPTA, there was used a bachelor course at Sofia University about XML technologies and languages. The instructional design of the course has two main streams - one intended for theorists, and another - for the opposite learning style, i.e. activists [25]. These two main paths in several sections are divided symmetrically in two others sub-paths and next merged again, in order to add LOs to them (respectively for activists and theorists) intended for both pragmatists and reflectors. Thus, there are provided sub-paths for any one of the four combinations (quadrants) of learning styles shown in fig. 2.

#### 3.2 Practical Experiments and Results

The experimental field trial described in [25] aims at evaluation of courseware delivery with learning style adaptation. In practical experiments participated 84 four-year students of the bachelor program in Software engineering at Sofia University, Bulgaria. The students were divided into two groups with equivalent average student performance shown by previous assessments. The first group was taught by several modules of a traditional, non-adaptive course in XML technologies given by Moodle. On other hand, the second one passed the same modules in adaptive mode using the ADOPTA platform and having appropriate instructional design for individual learning styles, i.e. containing paths with LOs most suitable for the four combinations of individual learning styles shown in fig. 2.

For the adaptive course, there were provided two assessment tests - one at intermediate control page
and another at the final one. Students taken the adaptive version of the same course demonstrated better performance - with 76.75% average result, while the first group showed 67.14%. By a questionnaire after the adaptive course there was proven that students find adaptive learning much more appealing and efficient. However, in order to evaluate its efficiency, evaluation of appropriateness of LOs types for different learning styles appears to be crucially important.

First at all, such a research should find dominant learning style in the context of the studied student group, namely, bachelors in Software Engineering. Fig. 3 represents average values of learning styles for the 42 bachelors participated into adaptive learning. As expected, such students are predominantly theorists and partially reflectors than activists and pragmatists, due to their mathematical background.

In conducted experiment, 38 of 42 students passed successfully the adaptive course modules in XML technology and have filled in a questionnaire. They have been asked what main types of learning objects do they prefer, where each student was allowed to have multiple choice, i.e. to select several LOs types. Next figure below shows students prefer much more exercise tasks and intermediate tests than writing essays and analyses, though their theorist-reflector learning style (fig. 3). As well, practical projects and educational games are welcome for more that the half of the students, which reveals their need of project- and game-based learning.

Results shown in fig. 4 called into question previously estimated level of suitability of LOs types for different learning styles shown in fig. 2. This imposed a more detailed analysis on studying dependency of preferred LOs types on learning styles. Fig. 5 reveals such dependency by showing average learning styles of students appreciated tasks, projects, essays, games and tests as valuable types of learning objects. These results demonstrate similar distribution of styles – predominantly theorist (about 80) and reflector (ca. 75) and less activist and pragmatist (ca. 60), excepting for essays. In fact, though only 6 students like essays as LO type, all of them show very high theorist level (for some it is the maximum value - 100) and rather high reflector style, which does confirm our initial assumptions as shown in fig. 2.
Fig. 6: Deviation of learning styles for preferred LOs types from average values

The results presented in fig. 5 are similar as far as they show average learning styles for students selected given type of LOs, which cannot be far from the average style presented in fig. 3. In order to reveal the real differences in styles of students voted for each one of the five object types, we have to investigate the deviation of learning styles for preferred LOs types from the average values. Fig. 6 presents extremely strong deviation from average theorist and reflector style for students preferring essays, which shows such type of LOs is strongly desired by learners with such predominant style. Theorists and reflectors like less projects and tasks but not at all intermediate tests. On other hand, activists and pragmatists like having tests but not tasks. It is interesting to point out that only reflective activists like playing educational games, contrary to the assumption that games are suitable for pragmatists.

Fig. 7: Preference of LOs types by learners with very predominant learning styles

Finally, it was interesting to find out what are the preferences of learners with very prominent learning styles, because strongly expressed learning style is important in finding clear trends. Here, under strongly expressed learning style there is accepted a style with value equal or greater than 80 according the questionnaire of Honey and Mumford giving 100 as a maximal value for a style. Fig. 7 shows the preference of LOs types by learners with very prominent learning styles. In fact, the numbers resemble these shown in fig. 4 but with distribution over styles.

Fig. 7 does not reveal the real dependency of LOs types on predominant styles because the vertical bars present only the number of learners with given style. Fig. 8 gives the relative preference of LOs types by learners with very prominent learning styles. Results seem different because here the bars show the percentage of learners with prominent style voted for tasks, projects, essays, games and tests. For example, 90% of strong activists like executing tasks, while 90% of strong pragmatists like solving tests. Games are preferred mainly by strong activists and reflectors. Only few of learners with prominent styles like essays but, if any, they are strong reflectors and theorists.

Fig. 8: Relative preference of LOs types by learners with very prominent learning styles

4 Discussion
Results presented in previous section reveal important issues about preferences of learners with different learning style. They are very important for adaptive courseware design as far as instructors should know the level of suitability of various types of learning objects for a given family of learning styles.

Assumed distribution of LOs types on learning style was proposed based on our teaching experience. However, real preference of types of LOs by learners is slightly different which imposes
some revisions over the initial distribution. Fig. 9 presents a revised view of the distribution taking into account the obtained results. It shows games are most suitable not for pragmatists but for reflectors, while essays are preferred not by activists but by theorists. As well, there are no available types of LOs for assessment appropriate for pragmatists.

Fig. 9: Revised distribution of learning objects to Honey&Mumford learning styles

5 Conclusion
The paper addressed practical evaluation of the role of learning styles on adaptive courseware delivery developed and executed in ADOPTA platform. More specially, it presented results about dependency of learning object types on learning styles, which plays a crucial role while constructing storyboards of adaptive e-learning courses. The obtained results are based on questionnaire about relevance of types of LOs filled by bachelor students in Software Engineering after passing an adaptive course developed and delivered by ADOPTA. They reveal a strong dependency of LOs types on styles. However, several remarks may be concluded here:

- First at all, the results are context-dependent – they depend on the average student profile. In cases where reflectors and theorists are not predominant, results may be rather different. As well, it has to pointed out that learning style of an individual is not fixed forever but upgrades with time.
- Some of the obtained results differ from the expected – it remember us always to count with real attitude of learners and their feedback
- Finally, it is under question whether students have to get preferable types of learning objects or, otherwise, types imposed by instructors following given pedagogical strategy. Probably, efficient solution should take into account both the pedagogical strategy and students preferences.

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