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THE STRUCTURAL WAY FOR BINDING A LEARNING MATERIAL WITH PERSONAL PREFERENCES OF LEARNERS

Yoshinov R., Iliev O. **The Structural Way for Binding a Learning Material with Personal Preferences of Learners.**

Abstract. Learning content creation process requires more than just collection and presentation of set of information. In order to gain knowledge, the learning content should be designed in such a way to meet predefined learning goals. Learning goals determine the entire process of learning. Bloom's Taxonomy provides a description of a cognitive process with six hierarchical levels, each containing specific learning goal to achieve. It could be adapted into a model by which tutors create learning materials. However, when it comes to productivity of learning, it is important to consider the personalization of the presented content according to the learning style of the individual. This article analyzes the correlation between Bloom's Taxonomy and Honey & Mumford's learning cycle, providing a way to bind the structure of learning material to the personal preferences of learners. This novel way of creating learning materials is integrated into a model that is used for automatic generation of personalized learning materials. The effectiveness of the model is further verified through an experiment with real participants. The results of the experiment show promising potential in the way of how a learner's capabilities may be enriched. However, while experimenting and rest of the work on the model outline some challenges before the model's application and future work.

Keywords: learning goals, bloom's taxonomy, Honey & Mumford learning cycle, learning materials, gamification, personalized learning process, A/B testing.

1. Introduction. Learning goals determine the entire process of learning. Goal priorities and goal dependencies when deciding what to learn, and how to coordinate multiple learning strategies improve the effectiveness of learning often changing the context in which the process of learning is being performed, as described in Section 2 "Importance of learning goals in the process of learning".

The process of learning content creation requires more than just information grouping. The learning content should be designed in such a way to meet predefined learning goals. Section 3 "Segregation of the learning content according to Bloom's Taxonomy model" provides a novel way to adapt the Bloom's Taxonomy to segregate a learning material to six parts, each of them setting a specific learning goal to achieve. The granulation of the learning content is made following the Wagner's [26] model and provides a way to reuse the created content.

In order to create a learning material, it is necessary to have some kind of source of learning content that is properly structured and described in advance so that the information there to be reusable. However, the existing repositories are not following a common standard and this interference their reusability. The advantages and disadvantages of the modern learning content management systems are overviewed into Section 4 “Source of learning content” as well as a novel data structure that can solve their limitation.

The process of learning cannot be universally applicable for all learners. Different learners perceive the information transmitted in various ways, and their performance is influenced by how the learning content is being served. Learning styles, presented into Section 4 “Personalizing the learning materials according to the cognitive abilities and the preferences of the learners”, aim to make complex tasks seem easy-looking, simply adapting the method of presentation of the information.

The segregation of the learning material following the adapted Bloom’s model would increase the productivity of the learners in the process of acquiring new knowledge. This productivity could be further enhanced when the segregated learning material is re-arranged in such a way as to follow a specific learning style appropriate for each of the different types of learners. A novel way to bind the structure of learning material to the personal preferences of learners is provided into Section 6 “Binding the structure of learning material to the personal preferences of learners”.

The model of segregation the learning content and re-arrange it to satisfy the preferences of the individuals having different learning styles, can be automated as described into Section 7 “Automatically generated learning materials”. When it comes to automation of a process, however, it is important to get feedback from the people who use the results of this process. In this way, the model that describes the process can be self-correcting in order to provide more accurate results. Section 8 “Ways to collect the learner’s feedback and increasing their motivation” provides a way to both motivate all the participants in the learning process and collect their feedback using so called “Gamification” strategy.

Section 9 “Example of the application of the model for automatically generated personalized learning materials” presents the model’s application into a real scenario — lesson in Informatics, in order to show its benefits and the way it is working.

The effectiveness of the presented model was verified through an experiment with real people described into Section 10 “Active experiments — A/B Testing approach”. These experiments show the practical potential of the presented model, but also together with the rest of the work on the model outline some “challenges before the model’s application and future work” as it can be seen in Section 11.

2. Importance of learning goals in the process of learning. Learning goals determine the entire process of learning. Goal priorities and goal dependencies when deciding what to learn, and how to coordinate multiple learning strategies improve the effectiveness of learning often changing the context in which the process of learning is being performed. It is also explicit in the formulation of the learning process, the search for information, hypothesis evaluation, and other aspects of learning. Learning strategies, represented as methods for achieving learning goals, can be chained, composed, and optimized, resulting in learning plans that are created dynamically, and pursued in a flexible manner [21]. Identifying or determining the learner’s goals and analyzing them into lower level learning goals is a very challenging task that is very difficult to be performed by the learner, and it is usually performed through the instructor’s intervention, based on the appropriate methods, and decomposing learner’s goals into lower level learning goals in order to facilitate the learning process. Previous knowledge, as well as previously acquired skills, are closely related to the learning objectives, measured directly by the use of tests, concept maps, portfolios, auditions, etc. — or indirectly, by means of self-reports, inventory of prior courses, experiences, and so on.

The learner’s goals should be taken into account both in the organization of a learning experience, and the selection of its underlying content — the learning objects. In order to be able to be selected during the personalization procedure, the learning objects should also be dependent on difficulty, domain, and the learning experience and educational level of the learner. Participation in learning activities which correspond with the proper use of associated learning resources and materials, explore the ability for their transformation into knowledge for the target learner, with regards to a domain, and preferred difficulty is highly dependent on his learning experience aligned with the corresponding educational level.

3. Segregation of the learning content according to Bloom’s Taxonomy model. Bloom's Taxonomy [4], and its revised version developed by Lorin Anderson [1] present a 6-level hierarchical classification of cognitive processes, taking place during the acquirement of a new piece of knowledge or skill, to gain expertise in a topic. Each level of Taxonomy presents a specific learning goal, described with key verbs (Table 1), helping the tutors to formulate questions, tasks, examples, definitions, etc. [1]. This model could be transferred into model by which tutors create learning materials — each such material should be composed of six parts needed to complete the process of learning some newly acquired knowledge, which should be relevant to the specific learning goal.

Table 1. Verbs describing the learning goals, typical for each cognitive domain, described in Bloom's Taxonomy model

Taxonomy Level	Verbs Describing the Learning Goal
Remembering	define, describe, identify, know, label, list, match, name, outline, recall, recognize, reproduce, state
Understanding	understand, comprehend, convert, defend, distinguish, estimate, explain, extend, generalize, give an example, paraphrase, summarize, translate
Applying	apply, change, compute, construct, demonstrate, discover, manipulate, operate, predict, prepare, produce, relate, show, solve, use
Analyzing	analyze, break down, diagram, deconstruct, differentiate, discriminate, illustrate, infer, select, separate
Evaluating	evaluate, appraise, conclude, compare, contrast, criticize, critique, interpret, justify, support
Creating	create, categorize, combine, compile, compose, devise, design, generate, modify, organize, plan, rearrange, reconstruct, reorganize, revise, rewrite, tell, write

The verbs that characterize the learning objectives defined in Bloom's Taxonomy levels are not universally applicable when it comes to drawing up the content of a certain learning material. The idea of hierarchical classification of learning as a cognitive process is to describe the way of acquiring new knowledge. When it comes to building up learning material, however, these verbs do not always work. For example, if a tutor prepares a job-specific assignment, he could use the "define" verb characteristic feature of the Taxonomy "remembering" process, but when the lesson is to be composed, it would be more appropriate to use the word "definition" that will clearly describe this part of the lesson associated with the "remembering" process. Moreover, the use of the set of verbs related to specific levels of Taxonomy, supplemented by nouns and overriding syllables, would increase the number of search terms that an automated content collection system could use. Such a system could search ready-made repositories with learning content for “definition” or the task of “defining” a specific problem.

The main components of the learning content model are as follows [26]:

– Content Asset: Content assets include “raw” media such as images, clippings, audio and video clips, and more.

– Information Object: Text passage, web page, etc. that focus on a single piece of information. Such a piece can explain a concept, illustrate a principle or describe a process.

– Learning Object: In the learning content model, the learning object is a collection of information objects that are assembled together to meet a learning goal.

– Learning Component: The learning component is a basic concept of things like lessons or courses that are related to meeting multiple learning goals at a higher level. They are a combination of several training sites.

– Learning Environment: The learning environment is a combination of learning content and technology that the learner interacts with. The combination of training components with communication tools and/or other functionalities that aim to provide online learning experience can be aggregated in a learning environment (like LCMS).

The individual parts that could be divided into a learning material following Bloom’s Taxonomy model can be considered as information objects (IOs) in the sense of Wagner’s model [26] (Figure 1), and the whole group forms a learning object (LO). This granulation of information objects will allow easy aggregation, and re-use of individual “pieces” of information (IOs) into complete lessons (LOs).

It is generally accepted that there is a relation between the size of the learning object and the possibility of its reuse. Well-granulated learning objects and components have the potential to be flexibly assembled into new learning objects, while whole courses are not suitable for use in different contexts [2]. This fact is also illustrated by the Figure 1. This article is based on this fact. One of the main shortcomings of modern learning systems is the use of ready-made training materials by teachers who upload entire lessons and/or exams in different finished files. This leads to limitations, both on the technological level – the content of the files cannot be easily indexed and searched by users of the training systems, which limits and even makes its reuse impossible, as well as in terms of conceptually granular level, as reuse a whole lesson is very difficult.

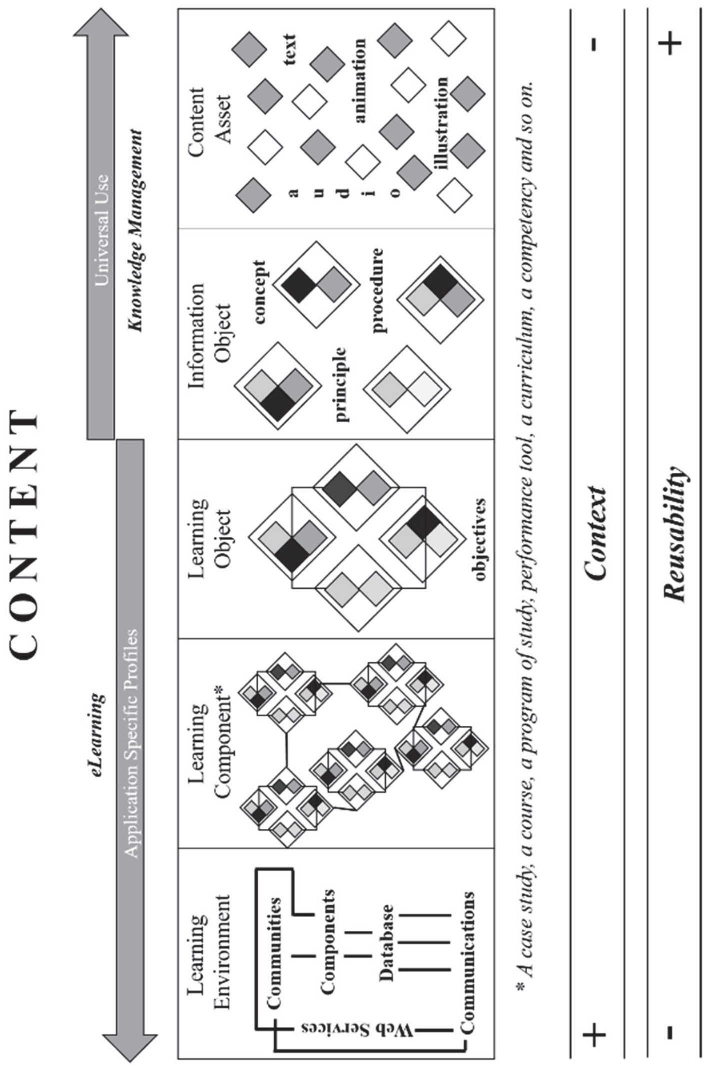


Fig. 1. Component based content model [26]

4. Source of learning content. In order to automate the creation of learning material, it is necessary to have some kind of source (repository) of information that is properly structured and described in advance so that the information there to be reusable. There are different kinds of sources of learning content determined by the type of information in them, how it is granulated and described. Unfortunately, most of these repositories do not follow a common standard for describing available content and their use is very difficult without a thorough knowledge of the repository's architecture. For the purposes of this article, the so-called Learning Content Management System (LCMS) will be addressed. In the context of the article, they will be referred to as repositories of information that could be reused to create new learning materials [28].

The advantage of LCMS kind of systems is that they already have content stored in them. Groups of lecturers, experts and trainees participate in their development — generating learning materials and assessing on the basis of feedback the credibility and relevance of these learning materials. In other words, the use of a ready set of information could be the fastest and most convenient way to create an automatic content generation system, as content will already be collected. However, their use has its limitations and disadvantages. Otherwise, teachers and experts have yet to fill in a content or create a “smart” automated system to crawl up a similar type of repository and “dig” information from there, structuring it and describing it more convenient for the automated learning system standard [28].

Before examining the advantages and disadvantages of LCMS, a review of the concept of the eLearning system and the components from which its architecture is designed will be reviewed [28].

4.1. eLearning System. Information and communication technologies have opened new horizons and opportunities for training and teaching, they overcome the problems and limitations of traditional approaches. In e-learning systems traditional forms of learning are enriched with new opportunities that have a strong technological foundation. They are complete eLearning infrastructures that allow the development, management and provision of advanced learning services at any time and everywhere [2].

The eLearning Systems can be divided primarily into two types, defined by their infrastructure, Learning Content Management Systems (LCMS) and Learning Management Systems (LMS). In modern electronic learning systems, however, these two functions are often mixed into a common “super” system.

LCMS focus on the creation, overfilling and management of learning content. They cover the complete cycle of collecting, delivering, managing and reusing training content in many different ways [17]. All these training systems use their own repository of learning objects/materials. They allow users to create, manage, search and reuse ready-made training materials [2]. These training materials can be small pieces of information — created within the user's system, following its standards of structuring and describing information. Such "pieces of information" are easy to index, search and reuse in different contexts from the same and/or other users. They can contain media files, tests, simulations, plain text, graphics, references to external sources [2]. Describing this kind of information related to learning material is achieved through standardized metadata structures that allow not only the re-use of the pieces" of information by the same or other users but also the sharing of information between different repositories of learning content. The truth, however, is that the use of this functionality of the LCMS is not a frequent practice by educators and experts. They typically do not create their training materials through the system where they are well described and structured, and more often use ready-made files created by them and just upload them to the system and complete the course content. Such file types are most often PowerPoint presentations, PDF/Word/Excel files, or archives from other files. Unfortunately, indexing, searching and reusing available information in these files is almost impossible. A number of obstacles face such a challenge, including the coding of the different formats, the lack of a metadata description. As a result, any kind of searching or indexing software cannot use the repository as a base.

In the training systems, the materials are granulated into small independent pieces that can be used alone or in combination with other materials to form higher level objects and meet the needs of the user [2]. Fundamental idea of learning objects is the lesson designer to create small components that can be reused many times in a different learning context [11]. Many publications claim that re-use not only saves money and time for trainers, but also enhances the quality of training materials. Just like the LEGO blocks, the idea is to create something small that can only be complete for itself but also easily combined with other components [11]. Learning Object (LO) should follow the rule that each unit should do only one thing and minimize the link with other units [5]. There is a general consensus that the learning object must be *Reused* (can be modified and used in different courses), *Accessible* (indexable and accessible by descriptive metadata), *Compatible* (operates on different hardware/software), *Durable* (to maintain proper operation after software or hardware upgrades) [18].

An important feature of the reusability and personalizability of training objects is their granularity [2]. However, the structure and content of learning objects is still unclear and possible to interpret in different ways [6, 20]. There is still an incomplete understanding of what a learning object is and how it differs from simple objects such as files, photos, videos, or a whole scientific report. When and at what level does an object become a learning object? What distinguishes learning objects from other learning materials? Because of the openness of these issues, there are different implementations of LOs [2]. An overview of existing models for identifying learning objects can be found in [3, 24, 25, 34].

4.2. A novel structure of a leaning repository that provides an appropriate level of granularity to allow easy re-use of the learning content. In order to meet the model requirements, set out in this article, a specific structure is proposed for describing learning materials with a set of metadata, described into Table 2 and Table 3. Thanks to such descriptions of information with descriptors it is possible to achieve full reusability of the teaching materials, their indexing and searching, as well as the automated generation of teaching materials, in relation to a predetermined topic [28].

Table 2 contains the descriptors that are describing learning material at the highest possible level. Every learning material (group of small pieces of learning content to form a IO) should be described with such kind of descriptors by its creator. On the other hand, Table 3 describes with metadata all the singles pieces (LO) of the IO on a lower level.

Table 2. Descriptors describing learning material at the highest possible level

Descriptor	Field Type	Example
Title	Text field	*Motion and rest of objects*
Key words	Text field	*motion of objects, motion and rest*

Table 3. Descriptors describing the individual learning objects associated with some learning material

Descriptor	Field Type	Example
Language	Language code selected from ISO 639-1	*en-US*
Learning goal	Value selected from a predefined list	*Definition*
Content	Text area field with the option of adding an image/video/audio or an external reference	*An object moves if it changes it position in time compared with another object.* *The object is at rest (it is still) if it does not change its position relative to the orientation.*
Complexity level	Low/Normal/High	*Normal*
Level of education	Value selected from a predefined list	*VI-th grade*
Learning context	Value selected from a predefined list	*Human and Nature*

The purpose of this metadata structure is to enable the teacher to create learning content on a particular topic in which to add different types of learning objectives. For example, if the teacher creates a learning content and gives him the title "Motion and rest of objects", he/she can add a definition to it, for example — descriptive information related to the learning content. Consequently, another tutor or the same one could search for previously created content and use it in another or the same context, but on a topic he or she defined. For example, the teacher could look for a "definition" and submit some keywords — search criteria. This will find all the existing content if there is one [28].

Filling in the content according to this structure of meta descriptors could also be done automatically by searching for existing repositories of learning materials from a "smart system" that recognizes the content of the information and classifies it according to the proposed architecture [28].

5. Personalizing the learning materials according to the cognitive abilities and the preferences of the learners. The process of learning cannot be universally applicable for all learners. Different learners perceive the information transmitted in various ways, and their performance is influenced by how the learning content is being presented. Some of them prefer to be engulfed in theory completely before continuing with the application of knowledge, while others prefer to gain new knowledge by solving specific problems. The different types of learners, and the type of cognitive processes that take place within their minds when acquiring new knowledge can be described by the so-called "learning styles". Learning styles are characterized by different methods of learning, organizing and understanding the information received from other people [7]. They do not deal with everyone's ability or the level of learners' intelligence, but they aim to make complex tasks seem easy-looking, simply adapting the method of presentation of the information [29].

In literature, there can be found several definitions of the concept learning style [15]. Learning styles might be generally defined as: the preferred attitude of the individual for organizing and presenting the information [22]; the various ways in which learners acquire, process, store, and recall knowledge. [14]; the distinctive types of behavior that serve as indicators of the way a person learns from and adapts to the environment, and also provides signs of how the human operates [9]; the attitudes and behavior that determine the preferable way of learning for the individual concerned [12]. As an example, a student learning how to program would rather start writing a code straight away in order to learn a new programming language, while another would prefer reading and learning the new language before he actually approaches real programming. Choosing a learner-friendly learning style provides an opportunity to customize the learning material in order to enhance productivity.

One way of classifying learners into their appropriate learning styles is to use the Kolb's learning cycle [16]. In his theory, Kolb considers the so-called experiential learning process, which is presented as a cycle of stages through which the learner passes in order to reach complete knowledge. In this way, Kolb divides the learners into four distinctive types – accommodators, divergers, convergers, and assimilators. According to him, effective learning can only be accomplished once the learner had passed through the entire four-stage cycle, but each learner can start his transition from each of the four stages, and follow the logical sequence of events to complete the circle [19].

Kolb's cycle was additionally developed by Honey & Mumford (1992), where apart from accepting changes to the correct model of introducing the correct type of learning content for the specific type of learner, a Learning Styles Questionnaire (LSQ) has been presented — serving as a blueprint for classifying the learners according to their most appropriate type of learning [30, 31, 33]. According to Honey & Mumford's learning cycle (Figure 2), the learners might be divided into four types — activists, reflectors, theorists, and pragmatists.

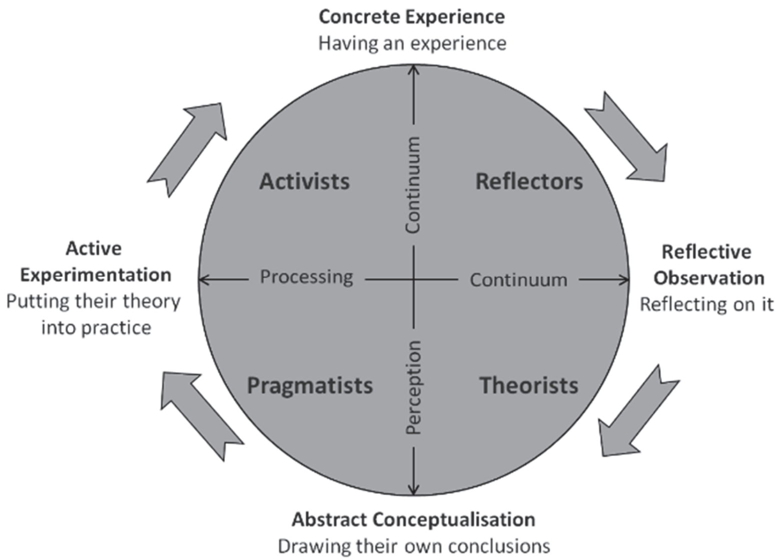


Fig. 2. Honey & Mumford's Learning Cycle

6. Binding the structure of learning material to the personal preferences of learners. The segregation of the learning material following the adapted Bloom's model would increase the productivity of the learners in the process of acquiring new knowledge. However, the productivity could be further enhanced when the segregated learning material is re-arranged in such a way as to follow a specific learning style appropriate for each of the different types of learners. In other words, the consistency of goals that should be placed on learners must be tied to the most appropriate for them learning style [32].

In one of his articles, James Gallagher presents the relationship between Kolb's learning cycle, and Bloom's Taxonomy [8]. He presents the idea that the different learning styles should go through all levels of the learning process — as defined by Bloom — even though in somewhat different sequence. The principle of crawling through the levels in a clockwise manner has been used, and a specific level appropriate to the various learning styles has also been used in order to start the cycle. This article uses Gallagher's work by updating the inherent model. Instead of using Bloom's original Taxonomy, its updated version was being implemented, and instead of Kolb's learning cycle, it integrates the one developed by Honey & Mumford (Figure 3).

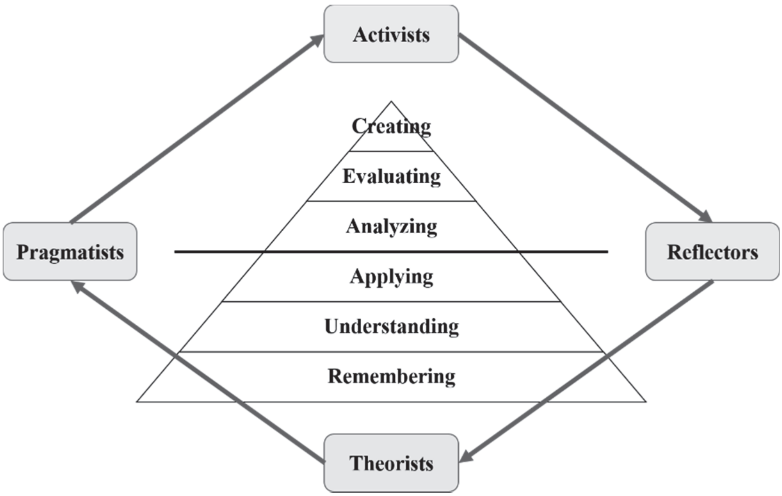


Fig. 3. An adapted Model of Gallagher [8] illustrating the relationship between the learning style, according to the Honey & Mumford's learning cycle, and the learning goals, according to the revised version of Bloom's Taxonomy

The sequence of processes defined in Bloom's Taxonomy through which the learners with different learning styles must pass, according to Honey & Mumford, is graphically presented in Figure 4.

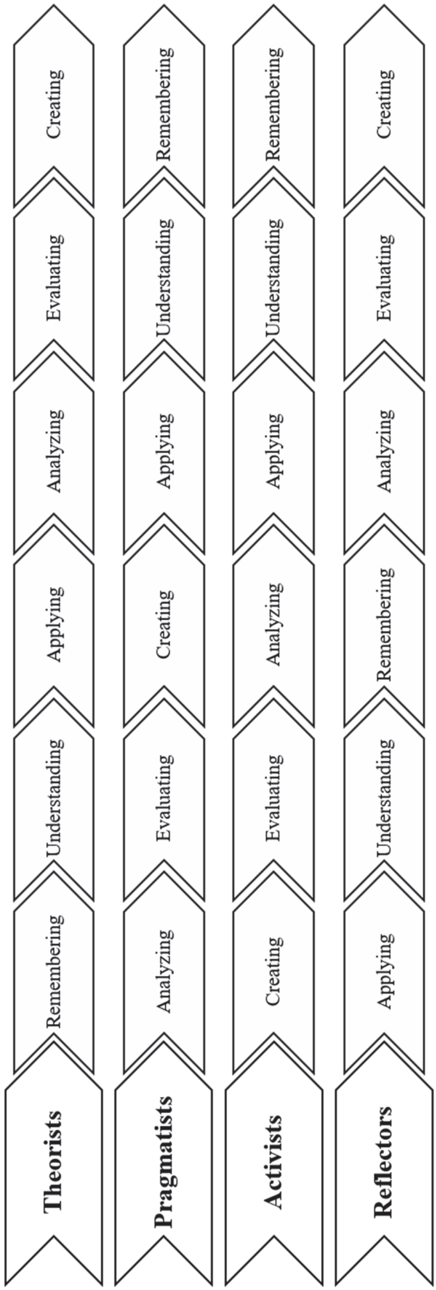


Fig. 4. The sequence of processes as defined in Bloom's taxonomy, through which people must pass for each learning style defined by Honey & Mumford's learning cycles

7. Automatically generated learning materials. The segregation of learning content, represented as a collection of different IOs, according to Wagner’s classification [26], which should meet each learner's specific learning goal in the process of acquiring new knowledge, allows the easy generation of learning content in the form of LOs. The model presented in this article aims to aggregate all necessary “pieces” of information to compile a new learning material following the model of cognitive processes as distinguished in Bloom's Taxonomy — a lesson should be composed of separate objects provoking the invocation of processes into the learner’s mind as: remembering, understanding, applying, analyzing, evaluating, and creating.

When it comes to aggregating individual IOs, there must be some source of learning content. The easiest option would be to have a repository of learning materials, created by the tutors, properly separated into individual components, allowing the reuse of each part, independently of other parts, in different lessons within different contexts. The tutors have to create the learning content in such a way that each individual part of it only refers to one type of cognitive process. For example, a learner could define a specific problem; to illustrate a definition by way of an example; to provoke learner to search for different options for its application in different situations; to set a task of analyzing the situation related to the particular problem; to stimulate learners to evaluate a specific solution to the problem based on their own knowledge, and to offer their own solution to a certain study case.

Another option is to use an automated search engine to look through the already-created arrays of information. The search engine should use a set of keywords describing the learning objectives per each level of Bloom's Taxonomy in a combination with the relevant context, and thus automatically generate the required small “pieces” of learning content. For example, the search engine could search for text containing keywords such as: definition, example, apply, analyze, rate, create, etc., in predefined context. Once the learning material is granulated according to the principles set out in the model presented in the article, it can be reused multiple times. Moreover, the sequence of presenting the individual IOs composing an LO can easily be altered. This allows the link between consistency in achieving the learning objectives, and the learning style discussed in the Section 6 “Binding the structure of learning material to the personal preferences of learners”.

The model represented in the article provides an opportunity for its thorough automation – from collecting the items of segregated learning content to meet a specific learning goal, to the principle of rearranging the individual parts of learning content in such a way as the final learning material meets the needs of each style of learning.

8. Ways to collect the learner’s feedback and increasing their motivation. When it comes to automation of a particular process, it is important to get feedback from the people who use the results of this process. In this way, the model that describes the process can be corrected in order to provide more accurate results. For this reason, the model presented in the article should provide a process of collecting feedback from the learners in order to evaluate each part of the lesson presented, as well as its complete set-up (LO). If a certain section of the lesson receives poor feedback, then it should not be reused again at the expense of other IOs that meet the same learning objective. What's more, this part of the lesson should be replaced ASAP in the overall architecture of the lesson, in order to achieve better productivity in the process of acquiring new knowledge.

One particular challenge encountered by each model for presenting new knowledge to the individual learners is their motivation. Of utmost importance for the learners is their productivity in acquiring new knowledge. Moreover, in a model that could require the manual generation of learning content by tutors, it is also important to pay attention to the level of tutors' motivation to generate IOs. One possible solution to these two problems is the so-called process of Gamification. Gamification can be defined as the application of game elements and principles in a non-game context [13]. These elements and principles have been typically used to increase consumer engagement with a company, website or idea, increase the productivity of the learning process, and much more. Many studies have shown that the implementation of gaming elements in a ready-made concept could have a very positive effect on its performance [10].

We can divide gamification into two types — structured and meaningful. Structural gamification is more widespread and easy to apply, so it's included in the model presented in this article. With it, different gaming elements are directly applied in a specific context. This is done in order to pass the user through some process or content, providing various stimulating elements in the passage steps. In education, such structural gamification is used to translate learners through learning content and learning process management. The gaming elements that are commonly used are points, levels, badges, leadership lists, and achievements. These elements can be directly applied to the learning context by providing learner points for every correct test response, for example. Different badges for the best essay in the whole class or even the whole school can be provided. Through these points and badges, learners climb to levels that are presented in a leader list — public for the whole school. The other type of gamification — meaningful, is more difficult to apply. It aims at adapting a process or content to gaming elements, gaming mechanics, and game way of thinking. Using it, the content or process is changed to be more gaming like. The most commonly used elements are adding history, challenges, mystery, and characters to a context. For example, in the educational context, the content could change by introducing a learner's goal, the challenges that he has to go through in order to reach it, a story that has mysteries and characters in it [23].

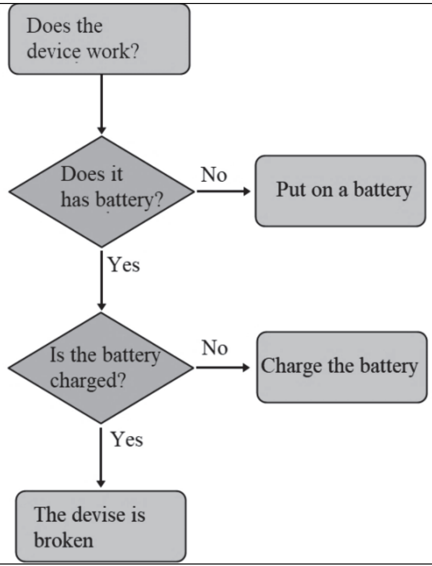
When gamification elements are introduced into the model, the motivation and knowledge of both learners and tutors could be enhanced. The first ones will obtain certain features symbolizing their success in going through different stages of learning, while the latter will be encouraged to improve their learning content. The public presentation of the results, which can be made visible to all participants in the process, is meant to provoke them to express naturally their innate desires for achieving success, competition, and/or cooperation with others [23].

9. Example of the application of the model for automatically generated personalized learning materials. Table 4 presents a lesson in Informatics — Flowcharts. The lesson considered as a LO has been decomposed into separate IOs responsible for each specific learning objective facing the learner.

Table 4. Separation of the LOs, partly needed to complete the process of getting knowledge, according to Bloom's Taxonomy, for a lesson presented in "Flowcharts"

Learning Objective	Keyword	Learning Content
Remembering	Definition	Flowcharts are diagrams that are used to make and record algorithms to be executed and achieve a corresponding result. They consist of geometric shapes, each of which has a definite meaning. In these figures, the data that the algorithm performer has to perform is entered. *Main elements:* – *Terminal* — Indicates the beginning and ending of a program or sub-process. Represented as a stadium, oval or rounded (fillet) rectangle. They usually contain the word "Start" or "End", or another phrase signalling the start or end of a process, such as "submit inquiry" or "receive product". – *Process* — Represents a set of operations that changes value, form, or location of data. Represented as a rectangle. – *Condition* — Shows a conditional operation that determines which one of the two paths the program will take. The operation is commonly a yes/no question or true/false test. Represented as a diamond (rhombus). – *Input/Output* – Indicates the process of inputting and outputting data, as in entering data or displaying results. Represented as a parallelogram (extra images).

Continuation of Table 4.

Understanding	Example	
Applying	Application	Find more information about flowcharts over the internet and write down three applications of flowcharts/algorithms in the real life?
Analyzing	Analysis	Analyze the results of the two algorithms displayed below. Why the are different? (two extra images)
Evaluating	Evaluation	Analyze the sorting algorithm displayed bellow using Big O Notation. (extra image)
Creating	Creation	Create an algorithm and design a flowchart, which finds a number in a set of numbers.

The individual IOs of the LO (the completed lesson) should be rearranged according to the sequence presented in Figure 4.

When presenting the learning material to the learner, continuous feedback about the information objects should be provided, as well as it replacement in the absence of accuracy. Moreover, the learner's achievement is distinguished for each successfully completed lesson, which aims to increase his/her dedication and motivation.

Using the model provided in the article, not only LOs that aim to generate new knowledge in learners can be created (like the one in the example presented in this section), but also assignments in order knowledge to be verified. In the second case, the model should work with IOs that are not so much of an explanatory nature, but formulating questions, and provoking independent action on behalf of learners. For example, for "remembering" learning goal, the automated system should not search for keyword "application" in a specific context, instead, the system should search for "apply" keyword.

10. Active experiments — A/B Testing approach. The effectiveness of the presented model was verified through an experiment with real people. To setup the experiment, a group of 112 participants were involved. They were at age between 13 and 14 — all of them in 7-th grade. The children were asked to read a learning material in flow charts, to make some examples, to research more about the problem over the Internet and finally to take an exam. They were rated with points between 1 and 30. The following section describes the experiment and analyse the accumulated data.

In order to provide more objective data, the experiment was made into a controlled environment and mostly dependent variables were used. Initial setup of the experiment:

– Children were in the same age group and in the same grade. Potentially, their background knowledge and skills are close to each other.

– 112 participants were involved. This large number of participants in the experiment provides the opportunity to reveal more accurate results.

– All the participants were asked to complete a questioner that defines their learning style, according to Honey & Mumford Learning Cycle.

– The learning material that the participants had to read is the one from the example given in this article. It is well granulated, following the principles by the Blooms Taxonomy, when convert the cognitive learning process to creation of a learning material. This allows both its reusability as a full and the reusability of each individual piece. Moreover, as the model presented into the article offers the content can be reordered in such way to satisfy the needs of every learning style.

– The evaluation of the participants was done thought a test, containing 30 questions. Every right question was giving 1 point to the participants. The wrong answers are not taking points out from the participant score.

– All the participants had the same maximum amount of time to read the learning material — 20 minutes and the same maximum amount of time to complete the test after reading it — 20 minutes.

To conduct the experiment, we decided to adapt so called A/B testing approach, also known as bucket testing or split-run testing. The testing approach is initially developed as a tool in web analytics, however, its main advantage is that it is easily integrated into web-based software environment. Such software environment was developed to make the experiment presented into this article.

A/B testing (Figure 5) provides a simple approach to compare two variants of a content. The participants of the experiment are divided into two groups – group A and group B. The first, group is called a control group. This group received the traditional (well known) variant of the content. The second, group is called treatment group. This group received the novel (opportunity) variant of the content. Since, this approach is technically adapted it allows the users to be separated into the groups randomly using their session with the server. It is also easy to manage what percentage of the users will be into the treatment group and what rests for the control group. Finally, the system can measure specific parameters that are later used to decide if the novel variant is better or worse than the traditional one.

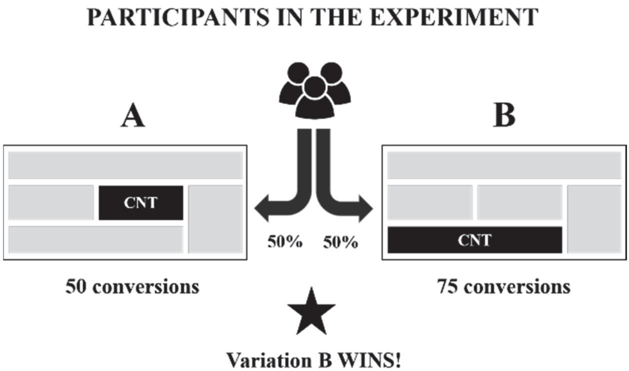


Fig. 5. Illustration of A/B Testing approach

Once the appropriate learning style of every participant were defined, further setup of the experiment was done:

– The controlled group size was set to 25% of all the participants – 28 participants. Pragmatically it was set this group to have equal number of representatives of each learning style — 7 theorists, 7 reflectors, 7 activists, and 7 pragmatists.

– The rest — 84, of the participants were into the treatment group. In this group, there were 16 theorists, 27 pragmatists, 24 activists, and 17 reflectors, according to their learning style.

Once the learning style of all the participants were defined and they were randomly separated into the groups, the actual experiment, were done:

– All the participants received the same learning material to read. However, the control group receive the learning material in its traditional order inducing the cognitive processes described by Bloom's Taxonomy into their regular order: *remember, understand, apply, analyse, evaluate, and create*. The participants into the treatment group received the material reordered, according to their learning style.

– All the participants were asked to take the same test after they read the learning material. The questions were into the same order for every participant.

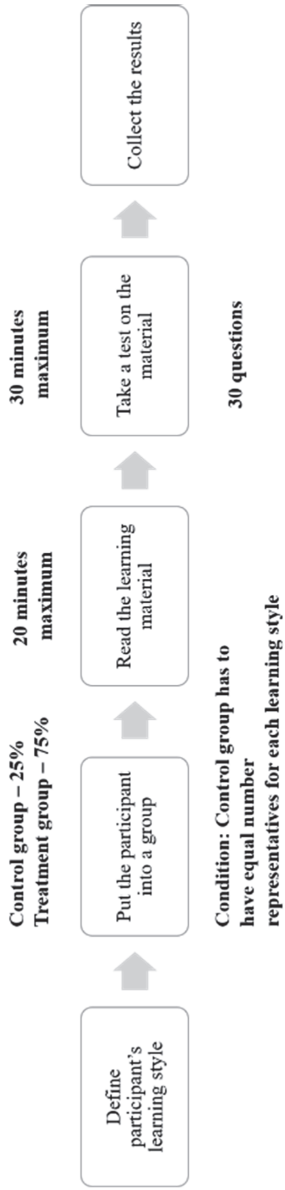


Fig. 6. Illustration of the experiment process

Result from the experiment:

After the experiment was made and the results (Figure 7) were analysed, it was noticed that the participants from the treatment group (the one using the model offered into the article) achieved about 12% better results than the participants from the control group (the one using the traditional way of structuring of learning material). This concludes that the model shows promising potential in the way of how a learner's capabilities may be enriched.

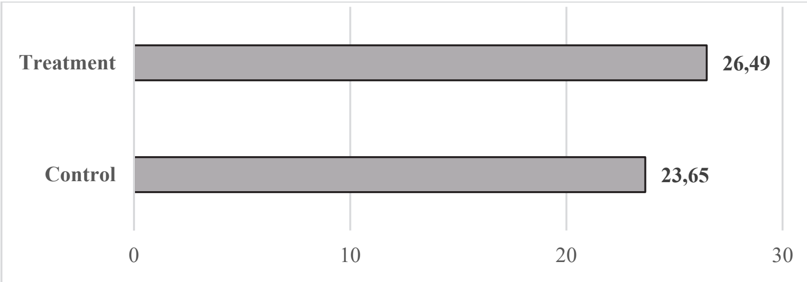


Fig. 7. Average results of the participants

11. Potential challenges before the model's application and future work. The main problem with the use of the model for automatically generating customized learning materials is the lack of pre-introduced content on the basis on which training materials to be created. Without the availability of data in the system's local repository, the preparation of teaching materials is much more difficult. This problem is caused by the lack of popularity of the model and its integration into existing learning systems. It could be overcome by creating algorithms for automated wagering, sifting and classifying educational information in external repositories. Another important condition to overcome the above mentioned problem is finding appropriate repositories as well as configuring the system to make it possible to use the information in these repositories. The most relevant are the repositories of already-in-the-real-world content management systems LCMS that have a broad community of users who use and evaluate both content-based and content-generating content [27].

Another potential problem with the model is the possible generation of insufficiently accurate training material as a result of the search of external sources where the information is not classified in advance according to the context, the expected educational level and the level of complexity of the content contained. This problem is envisaged and the model is potentially integrated in the model – the user's ability to request the system to re-search and replace a specific information object (IO), part of the training presented. Moreover, the system has the obligation to reflect the user's request to replace the information in order to “teach” the system and store relevant content in the local repository [27].

A problem faced by the model is shared by all existing LMS and LCMS – we cannot be sure of the relevance of the curriculum. Because users who can create learning content themselves determine whether their input is correct, users who use this training information can also not be sure of the content they provide. A potential solution to this problem is embedded in the model with the introduction of an opportunity to provide feedback from trainees on the training they are offered. This feedback is further tied to gamification affiliates. The model adapts it to the results of the gamification analysis and provides these information objects, which are part of the most positive feedback trainings. In this way, the “maturity” of the introduced content is evaluated [27].

12. Conclusion. Identifying or determining the learner’s goals and analyzing them into lower level learning goals is a very challenging task that is very difficult to be performed by the learner. It is usually performed through the instructor’s intervention, based on the appropriate methods.

The adaptation of the Bloom’s Taxonomy in a type of model to create learning materials, composed by six parts needed to complete the process of learning newly acquired knowledge, which should be relevant to the specific learning goal, seems to be potential way to granulate the content into small individual, independent and reusable pieces. However, the right granulation and creating learning materials that achieve the right learning goals is not enough when it comes to individuals with different learning styles. This article analyzes the correlation between Bloom’s Taxonomy and Honey & Mumford’s learning cycle, providing a way to bind the structure of learning material to the personal preferences of learners.

The model described into the article may be fully automated. It is able to generate learning material from scratch using a proper search engine and filling in a repository of learning content. The collected information could be classified by its type in sense of a learning goal and then arranged, following the right order, according a specific learning style, into ready learning material. When it comes to automation of a particular process, however, it is important to get some feedback from the individuals who use the results of this process. In this way, the model that describes the process can be self-correcting in order to provide more accurate results. This article provides a way to both motivate all the participants in the learning process and collect their feedback using so called “Gamification”.

The example of model’s application with a lesson in Informatics – Flowcharts, presents all the processes which takes part of the model and shows its potential. The same example is used as a learning content base of a real experiment with more than 100 participants. This experiment verifies the effectiveness of the model, showing promising potential in the way of how a learner's capabilities may be enriched. However, while experimenting and rest of the work on the model outline some challenges before the model's application and future work.

References

1. Lee Y.J. et al. East-Asian Primary Science Curricula: An Overview Using Revised Bloom's Taxonomy. Springer. 2016. 81 p.
2. Arapi P. Supporting Personalized Learning Experiences on top of Multimedia Digital Libraries. Ph.D. Thesis. 2017. 277 p.
3. Balatsoukas P., Moris A., O'Brien A. Learning objects update: Review and critical approach to content aggregation. *Journal of Educational Technology & Society*. 2008. vol. 11. no. 2. pp. 119–130.
4. Morton D., Colbert-Getz J. Measuring the impact of the flipped anatomy classroom: The importance of categorizing an assessment by Bloom's taxonomy. *Anatomical sciences education*. 2017. vol. 10. no. 2. pp. 170–175.
5. Boyle T., Cook J. Learning objects, pedagogy and reuse. Learning technology in transition. From individual enthusiasm to institutional implementation. 2003. pp. 31–44.
6. Knight C., Gašević D., Richards G. Ontologies to integrate learning design and learning content. *Journal on Interactive Media in Education*. 2005. vol. 2005. pp. 1–24.
7. Coffield F., Moseley D., Hall E., Ecclestone K. Learning styles and pedagogy in post-16 learning: a systematic and critical review. Learning and Skills Research Centre 2004. 173 p.
8. Gallagher J. The Business Case Study: A Suitable Candidate For Blended Learning? *Journal of Business Case Studies*. 2006. vol. 2. no. 4. 14 p.
9. Gregoric A. Learning/teaching styles: Potent forces behind them. *Educational Leadership*. 1979. pp. 36–40.
10. Hamari J., Koivisto L., Sarsa H. Does Gamification Work? – A Literature Review of Empirical Studies on Gamification. Proceedings of the 47th Hawaii International Conference on System Sciences (HICSS). 2014. pp. 3025–3034.
11. Hodgins W. The future of learning objects. The Instructional Use of Learning Objects Bloomington: IN: AECT. 2002. pp. 281–298.
12. An D., Carr M. Learning styles theory fails to explain learning and achievement: Recommendations for alternative approaches. *Personality and Individual Differences*. 2017. vol. 116. pp. 410–416.
13. Huotari K., Hamari J. Defining gamification: a service marketing perspective. Proceedings of the 16th International Academic MindTrek Conference. 2012. pp. 17–22.
14. James W.B., Gardner D.L. Learning styles: Implications for distance learning. *New directions for adult and continuing education*. 1995. vol. 1995. no. 67. pp. 19–31.
15. Karagiannidis C., Sampson D. Adaptation rules relating learning styles research and learning objects meta-data. Workshop on Individual Differences in Adaptive Hypermedia. 3rd International Conference on Adaptive Hypermedia and Adaptive Web-based Systems (AH2004). 2004. pp. 66–73.
16. Kolb D.A. Experiential Learning: Experience as the Source of Learning and Development: 2nd ed. Pearson FT Press. 2004. 416 p.
17. Lennox D. Managing Knowledge with Learning Objects. WBT Systems White Paper. 2001. 12 p.
18. Mason R., Rehak D. Keeping the learning in learning objects. Reusing online resources: a sustainable approach to e-learning. 2003. pp. 20–34.

19. McLeod S.A. Kolb's Learning Styles and Experiential Learning Cycle. 2017. 5 p. Available at: https://www.simplypsychology.org/simplypsychology.org-Kolb-Learning-Styles.pdf (accessed: 06.07.2018.).
20. Metros S.E. Learning objects: A rose by any other name. *Educause Review.* 2005. vol. 40. no. 4. pp. 12–13.
21. Ram A., Leake D. Goal-Driven Learning. The MIT Press. 1995. 61 p.
22. Riding R., Rayner S. Cognitive styles and learning strategies: Understanding style differences in learning and behaviour. David Fulton Publishers. 1998. 217 p.
23. Robson K. et al. Is it all a game? Understanding the principles of gamification. *Business Horizons*. 2015. vol. 58. no. 4. pp. 411–420.
24. Verbert K., Duval E. Towards a Global Component Architecture for Learning Objects: A Comparative Analysis of Learning Object Content Models. EdMedia: World Conference on Educational Media and Technology. Association for the Advancement of Computing in Education (AACE). 2004. pp. 202–208.
25. Verbert K., Duval E. ALOCOM: a generic content model for learning objects. *International Journal on Digital Libraries.* 2008. vol. 9. no. 1. pp. 41–63.
26. Wagner E.D. Steps to creating a content strategy for your organization". *The e-Learning developers' journal*. 2002. 9 p.
27. Yoshinov R., Iliev O. "Controlled self-study" in thematic educational community environment. Proceedings of the Forty-seventh Spring Conference of the Union of Bulgarian Mathematicians. 2018. pp. 200–213.
28. Yoshinov R., Iliev O. Content reuse - a major problem with modern content storage systems. Eleventh National Conference with International Participation "Education and Research in the Information Society". 2018.
29. Yoshinov R., Kotseva M., Pavlova D. Specifications for Centralized DataCenter serving the educational cloud for Bulgaria. International conference ETAI. 2015. pp. 1–6.
30. Yoshinov R., Kotseva M. The steps for elaboration of the "Rosetta stone" demonstrator. Proceedings of International Conference Inspiring Science Education. 2016. pp. 91–96.
31. Yoshinov R., Arapi P., Kotseva M., Christodoulakis S. Supporting Personalized Learning Experiences on top of Multimedia Digital Libraries. *International journal of education and information technologies*. 2016. vol. 10. pp. 152–158.
32. Yoshinov R., Pavlova D., Kouzov O. Reflection of ISE idea for linking school education and scientific research in the National Strategy for effective implementation of ICT in education and science in the Republic of Bulgaria. Proceedings of International Conference Inspiring Science Education. 2016. pp. 129–134.
33. Yoshinov R., Kotseva M. Vision for the Engagement of the e-Facilitator in School in the Inspiring Science Education Environment. *Serdica Journal of Computing*. 2015. vol. 9. no. 3-4. pp. 241–256.
34. Trifonov R., Yoshinov R., Jekov B., Pavlova G. Methodology for Assessment of Open Data. *International Journal of Computers*. 2017. vol. 2. pp. 28–37.

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СТРУКТУРНЫЙ СПОСОБ И МОДЕЛЬ АВТОМАТИЧЕСКОЙ ГЕНЕРАЦИИ ПЕРСОНАЛИЗИРОВАННЫХ УЧЕБНЫХ МАТЕРИАЛОВ

Йошинов Р.Д., Илиев О.П. **Структурный способ и модель автоматической генерации персонализированных учебных материалов.**

Аннотация. Определение целей обучения и их анализ — довольно сложная задача, которую учащемуся трудно решить самостоятельно. Расстановка целевых приоритетов того, что нужно изучать и какие стратегии обучения сочетать между собой, повышают эффективность получения новых знаний, часто изменяя контекст учебного процесса. Создание учебного контента требует не только сбора и представления информации — для приобретения знаний контент должен быть разработан таким образом, чтобы соответствовать заранее определенным целям обучения. Чтобы подготовить учебный материал, необходимо иметь источник учебного контента, который правильно структурирован и описан заранее, однако существующие хранилища не соответствуют общему стандарту, что мешает их повторному использованию. Таксономия Блума описывает когнитивный процесс с шестью иерархическими уровнями, каждый из которых содержит определенную цель обучения. Он может быть адаптирован к модели, посредством которой преподаватели подготавливают учебные материалы, однако когда дело доходит до продуктивности обучения, важно учитывать персонализацию представленного контента в соответствии со стилем обучения человека. В статье анализируется модель создания учебным материалов, основанная на таксономии Блума и цикле обучения Хони и Мамфорда. Описанную модель можно полностью автоматизировать и приспособить к самостоятельной генерации учебных материалов, используя подходящую для этого поисковую систему и закрытые репозитории учебного контента. Собранная информация может быть классифицирована по цели обучения, а затем упорядочена в соответствии со стилем обучения в готовый учебный материал. Эффективность модели дополнительно подтверждается экспериментом с реальными участниками, и результаты эксперимента показывают многообещающий потенциал расширения возможностей учащегося.

Ключевые слова: цели обучения, таксономия Блума, учебный цикл Хони и Мамфорда, учебные материалы, игрофикация, персонализированный процесс обучения, тестирование A/B.

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Литература

1. *Lee Y.J. et al.* East-Asian Primary Science Curricula: An Overview Using Revised Bloom's Taxonomy // Springer. 2016. 81 p.
2. *Arapi P.* Supporting Personalized Learning Experiences on top of Multimedia Digital Libraries // Ph.D. Thesis. 2017. 277 p.
3. *Balatsoukas P., Moris A., O'Brien A.* Learning objects update: Review and critical approach to content aggregation // Journal of Educational Technology & Society. 2008. vol. 11. no. 2. pp. 119–130.
4. *Morton D., Colbert-Getz J.* Measuring the impact of the flipped anatomy classroom: The importance of categorizing an assessment by Bloom's taxonomy // Anatomical sciences education. 2017. vol. 10. no. 2. pp. 170–175.
5. *Boyle T., Cook J.* Learning objects, pedagogy and reuse // Learning technology in transition. From individual enthusiasm to institutional implementation. 2003. pp. 31–44.
6. *Knight C., Gašević D., Richards G.* Ontologies to integrate learning design and learning content // Journal on Interactive Media in Education. 2005. vol. 2005. pp. 1–24.
7. *Coffield F., Moseley D., Hall E., Ecclestone K.* Learning styles and pedagogy in post-16 learning: a systematic and critical review // Learning and Skills Research Centre 2004. 173 p.
8. *Gallagher J.* The Business Case Study: A Suitable Candidate For Blended Learning? // Journal of Business Case Studies. 2006. vol. 2. no. 4. 14 p.
9. *Gregoric A.* Learning/teaching styles: Potent forces behind them // Educational Leadership. 1979. pp. 36–40.
10. *Hamari J., Koivisto L., Sarsa H.* Does Gamification Work? – A Literature Review of Empirical Studies on Gamification // Proceedings of the 47th Hawaii International Conference on System Sciences (HICSS). 2014. pp. 3025–3034.
11. *Hodgins W.* The future of learning objects // The Instructional Use of Learning Objects Bloomington: IN: AECT. 2002. pp. 281–298.
12. *An D., Carr M.* Learning styles theory fails to explain learning and achievement: Recommendations for alternative approaches // Personality and Individual Differences. 2017. vol. 116. pp. 410–416.
13. *Huotari K., Hamari J.* Defining gamification: a service marketing perspective // Proceedings of the 16th International Academic MindTrek Conference. 2012. pp. 17–22.
14. *James W.B., Gardner D.L.* Learning styles: Implications for distance learning // New directions for adult and continuing education. 1995. vol. 1995. no. 67. pp. 19–31.
15. *Karagiannidis C., Sampson D.* Adaptation rules relating learning styles research and learning objects meta-data // Workshop on Individual Differences in Adaptive Hypermedia. 3rd International Conference on Adaptive Hypermedia and Adaptive Web-based Systems (AH2004). 2004. pp. 66–73.
16. *Kolb D.A.* Experiential Learning: Experience as the Source of Learning and Development: 2nd ed. // Pearson FT Press. 2004. 416 p.
17. *Lennox D.* Managing Knowledge with Learning Objects // WBT Systems White Paper. 2001. 12 p.
18. *Mason R., Rehak D.* Keeping the learning in learning objects // Reusing online resources: a sustainable approach to e-learning. 2003. pp. 20–34.
19. *McLeod S.A.* Kolb's Learning Styles and Experiential Learning Cycle. 2017. 5 p. URL: https://www.simplypsychology.org/simplypsychology.org-Kolb-Learning-Styles.pdf (дата обращения: 06.07.2018.).
20. *Metros S.E.* Learning objects: A rose by any other name // Educause Review. 2005. vol. 40. no. 4. pp. 12–13.
21. *Ram A., Leake D.* Goal-Driven Learning // The MIT Press. 1995. 61 p.

22. *Riding R., Rayner S.* Cognitive styles and learning strategies: Understanding style differences in learning and behaviour // David Fulton Publishers. 1998. 217 p.
23. *Robson K. et al.* Is it all a game? Understanding the principles of gamification // Business Horizons. 2015. vol. 58. no. 4. pp. 411–420.
24. *Verbert K., Duval E.* Towards a Global Component Architecture for Learning Objects: A Comparative Analysis of Learning Object Content Models // EdMedia: World Conference on Educational Media and Technology. Association for the Advancement of Computing in Education (AACE). 2004. pp. 202–208.
25. *Verbert K., Duval E.* ALOCOM: a generic content model for learning objects // International Journal on Digital Libraries. 2008. vol. 9. no. 1. pp. 41–63.
26. *Wagner E.D.* Steps to creating a content strategy for your organization" // The e-Learning developers' journal. 2002. 9 p.
27. *Yoshinov R., Iliev O.* "Controlled self-study" in thematic educational community environment // Proceedings of the Forty-seventh Spring Conference of the Union of Bulgarian Mathematicians. 2018. pp. 200–213.
28. *Yoshinov R., Iliev O.* Content reuse - a major problem with modern content storage systems // Eleventh National Conference with International Participation "Education and Research in the Information Society". 2018.
29. *Yoshinov R., Kotseva M, Pavlova D.* Specifications for Centralized DataCenter serving the educational cloud for Bulgaria // International conference ETAI. 2015. pp. 1–6.
30. *Yoshinov R., Kotseva M.* The steps for elaboration of the "Rosetta stone" demonstrator // Proceedings of International Conference Inspiring Science Education. 2016. pp. 91–96.
31. *Yoshinov R., Arapi P., Kotseva M., Christodoulakis S.* Supporting Personalized Learning Experiences on top of Multimedia Digital Libraries // International journal of education and information technologies. 2016. vol. 10. pp. 152–158.
32. *Yoshinov R., Pavlova D., Kouzov O.* Reflection of ISE idea for linking school education and scientific research in the National Strategy for effective implementation of ICT in education and science in the Republic of Bulgaria // Proceedings of International Conference Inspiring Science Education. 2016. pp. 129–134.
33. *Yoshinov R., Kotseva M.* Vision for the Engagement of the e-Facilitator in School in the Inspiring Science Education Environment // Serdica Journal of Computing. 2015. vol. 9. no. 3-4. pp. 241–256.
34. *Trifonov R., Yoshinov R., Jekov B., Pavlova G.* Methodology for Assessment of Open Data // International Journal of Computers. 2017. vol. 2. pp. 28–37.