A 3D MODEL AS A TOOL FOR INCREASING THE EFFECTIVENESS OF E-LEARNING*

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ABSTRACT. The paper proposes a 3D model which could be used as a tool for increasing the effectiveness of e-learning. It also offers an approach for applying this 3D model for increasing the effectiveness of e-learning. This approach has methodical value in line with the idea for dynamic adjustment of the individual learning profile of each student in order to increase the personalization level in the e-learning process.

1. Introduction. The advent of e-learning is a consequence from the increasing necessity of a learning process which is effective, flexible, adaptive to the individual student's learning style and accessible everywhere and at any

time. The interest in e-learning problems, common aspects and applications is continuously increasing.

The effectiveness of e-learning depends on the quality and quantity of the applied e-learning materials, the time needed for taking the course and the results at the course's end. When the time necessary for learning the new information in a given course is shorter and the results at the end are better, then the effectiveness of e-learning is higher. There are plenty of models, methods and tools for assessment of the effectiveness of e-learning [1, 3, 4, 5, 6, 7], but mostly they assess only a specific aspect of the e-learning process and do not offer a definite methodology for application with an opportunity for quality assessment.

Based upon the method for effectiveness of e-learning assessment proposed by the authors [7, 8] research was made among Bulgarian university specialists working in the filed of e-learning. A general conclusion that the authors made after processing the results was that ***one of the most important factors for effective e-learning is ensuring personalization of the offered e-learning services.***

A serious problem nowadays in e-learning is the lack of personalization of the teaching and learning processes. On the Internet one can find countless courses on the same topic, presented in different ways, with different level of use of multimedia elements, directed to different learning styles, with different duration and complexity. The user has a very difficult task: to find in the ocean of e-learning courses the most appropriate for his learning style, basic knowledge and skills. This is not always possible, and even when the choice of an appropriate course is a fact, there is little chance that the initial goal (gaining knowledge and skills in a given field) is reached in a short time. It is necessary to create an approach which will ensure the acquisition of knowledge (skills and competences) and the opportunity for preliminary selection from a great number of e-learning modules with the aim for personalization of the e-learning environment according to the individuality of each student and his expectations about the final results.

The personalization in e-learning may be described as a composition of procedures, approaches and techniques for providing students with the tools for self-learning, which will give them the opportunity to study according to their own capabilities, learning style, knowledge and skills, to choose the type of e-learning material and the way of presentation of the new material according to their own interests, needs and learning style.

One of the approaches for improving the personalization in the e-learning process is ensuring access to appropriate e-learning materials, according to the

individual learning style of the student. The learning style is the way of adoption and processing of the information. Every person develops a preferred and successful behaviour and concrete approaches for studying. This relates to three processes, which form the differences of style:

— **knowledge** – how the knowledge is acquired;

— **conceptualization** – how the information is processed;

— **motivation and emotions** – the way of making decisions and emotional preferences [1].

2. 3D model for e-learning: background and main concepts.

This paper presents a new 3D model for e-learning in order to solve some of the problems related to the lack of personalization that were discussed in the introduction. This model is based on the following circumstances:

→ **Each student has an individual learning style.**

The learning style reflects the way of absorbing and processing the information. There are many theories on the learning style. Here we use the so-called perceptual modalities or learning styles, defined according to sense perceptions (this is part of the theory of Dunn&Dunn) [1].

There are three basic modalities of processing information to memory: visual (learning by seeing), auditory (learning by hearing) and kinesthetic (learning by doing). Each of these different types of learning and absorbing the new information has specific characteristics.

The human being has the three modalities but in different ratios. Many students do not know their dominant learning style. This is a very serious problem when searching for learning material appropriate for them. When the e-learning system "knows" the individual learning style of a given student, it can select and offer the most appropriate learning content.

→ **Formalism and low level of personalization in the traditional form of learning – each curriculum consists of N disciplines distributed in K educational years.**

Regardless of the educational level and form of studying, the curriculum and syllabus are defined beforelied. The student has to pass successfully all disciplines, i.e. to gain all credits according to the ECST (European Credit Transfer and Accumulation System) in order to obtain the relevant qualification level.

In the traditional form of studying, the teaching is performed in front of a group of students with different learning styles. In most cases, despite the

teachers' professionalism and willingness to work individually with each student, the personalization is very low. The education period is fixed and it does not depend on the speed of adoption of the new material by the different students.

> → **In order to increase the effectiveness of e-learning, it should offer students the freedom to choose the most relevant learning content and also a great variety of learning materials.**

We present a 3D model of e-learning in this report in order to decrease the formalism of the studying process and also to increase the personalization and intensification level.

The necessity to choose a teaching impact is defined by the student's specific ability to absorb information and to acquire new knowledge. The goal to acquire a definite measurable level of competence requires the students to choose the way of "transforming" the input competence level to the expected output level. A study plan is developed for each transformation, which consists of a definite number of courses, arranged in a methodical chain to ensure the required level.

Description and visualization of the model. The model of the most effective way of studying according to the different learning modalities is defined in the space of the learning process state. The space is three-dimensional and each of the axes presents the effectiveness vector, which is defined as an ordered triple of:

{discipline, course version for a given discipline, the prognosticated assessment for effectiveness of the e-learning process}.

The goal of the modelling process is to define and to visualize the surface of the effective e-learning by prognosis assessment for the e-learning effectiveness.

The prognosis is realized by comparison between two vectors on the basis of scalar subtraction:

> → **Vector of the teaching impact and**
> → **Vector of the student's learning style.**

The Vector of the teaching impact in the model presents the quantitative assessment of the teaching characteristics of each version of the courses. The Vector of the teaching impact and the Vector of the student's learning style are chosen with the same dimension (L), and each of the coordinates (p) from 1 to L presents a connected set of properties impact/modality, respectively for the Vector of the teaching impact and the Vector of the learning style. For example, if property 1 of the Vector of the teaching impact presents "presenting the new knowledge by graphics", then the Vector of the learning style will be defined as

an analogical modality "ability of the student to learn effectively by graphical presentation of the new knowledge".

In this way other modalities and approaches for presentation of data could be defined and presented in the model such as: presentation and absorption of knowledge by text description, voice and sound, animation, problem solving, simulators, games, etc.

An unique Vector of teaching impact $\boldsymbol{VE_{ij}(1, L)}$ is defined for each version $\boldsymbol{j}$ of a given course $\boldsymbol{i}$. A Vector of learning style $\boldsymbol{VS_k(1, L)}$ is formed for each student $\boldsymbol{k}$.

The prognosis assessment of the effectiveness of e-learning for each version $\boldsymbol{j}$ of each course $\boldsymbol{i}$ and student $\boldsymbol{k}$, $\boldsymbol{LD_{ijk}}$, is defined by the following formula (1):

$$(1) \qquad LD_{ijk} = \sum_{p=1}^{L} \mid VE_{ij}(p) - VS_k(p) \mid \quad i \in \{1, N\}, j \in \{1, M\}$$

For each student $\boldsymbol{k}$, the M-scalar assessment is processed and according to (2) the course version $LD_{ij_{best}k}$ is found where the scalar assessment is minimal:

$$(2) \qquad LD_{ij_{best}k} = \min\left(LD_{ijk}\right), \quad j \in \{1, M\}$$

The minimal value of the scalar assessment corresponds to the minimal absolute discrepancy between the teaching impact of the concrete course version and the learning style of the student $\boldsymbol{k}$.

Applying criterion (2) for each course $i \in \{1, N\}$ course versions most appropriate for the student's $\boldsymbol{k}$ learning style are formed.

In visualizing the 3D model the points which are presented with ordered triple of coordinates for student k are approximated with parts of planes – Fig. 1: $\{\boldsymbol{i}$-course, $\boldsymbol{j}$-version, $\boldsymbol{LD_{ijk}}$ – scalar assessment according (1)$\}$

The graphical result of the visualization presents applying the criterion (2) and the possibility to prognosticate the way of defining $LD_{ij_{best}k}$ versions for $\boldsymbol{i}$ courses. The presented result is a surface of the effective e-learning. Very clearly marked local minima present the versions of the courses for which the student k will have least difficulties in absorbing the learning content and the effectiveness of the learning process is expected to be maximal – Fig. 1. Fig. 2 shows the opposite – the course versions for the same student which are most difficult for him, according to his learning style. The learning styles used for visualizing the model are exemplary. It is not the subject of this paper to present tools and methods for defining learning styles.
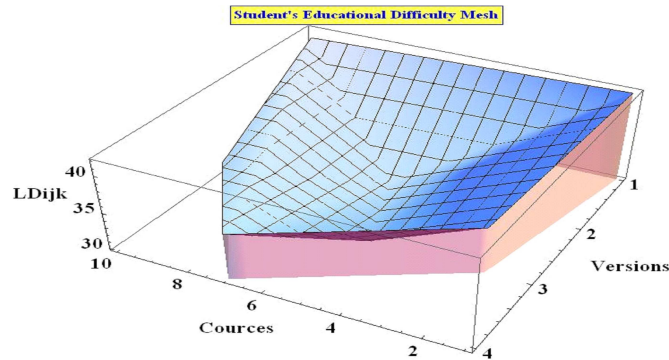
Fig.1. Course versions in which the student k will have least learning difficulties

The results presented in Fig. 1 and Fig. 2 are for one student, 10 courses in the curriculum, and from 1 to 5 versions for each course.

3. One approach for applying the 3D model of e-learning.
The approach presented on Fig. 3 consists of 7 stages [10]:

Stage 1 – the e-modules (E-module $1 - n$) are described by experts with metadata (E-module metadata) and are stored in a database (E-learning DB). The experts are teachers doing research in the field of e-learning.

Stage 2 – includes the student's registration and determination of his individual learning style. This is presented in the approach by the data structure SLP IDj.

Stage 3 – includes the student's request for learning (the request is presented in the approach by KSR ID_i).

Stage 4 – at this stage the 3D simulator defines the best versions of the existing e-learning modules for the individual learning style of each student by applying the 3D module. The input data for the simulator are the student's request KSR ID_i and the student's learning profile SLP ID_j.

Stage 5 – the selected most effective e-learning module is offered to the student and the online activities are started.

Stage 6 – includes an opportunity for actualization of the student profile. It is possible to change the input data about the student's learning style because of external factors.

Stage 7 – end of the session and saving the updated information.

Fig. 3 presents a flowchart of an e-learning personalization approach with a preliminary processing and simulation of the teaching and learning processes for
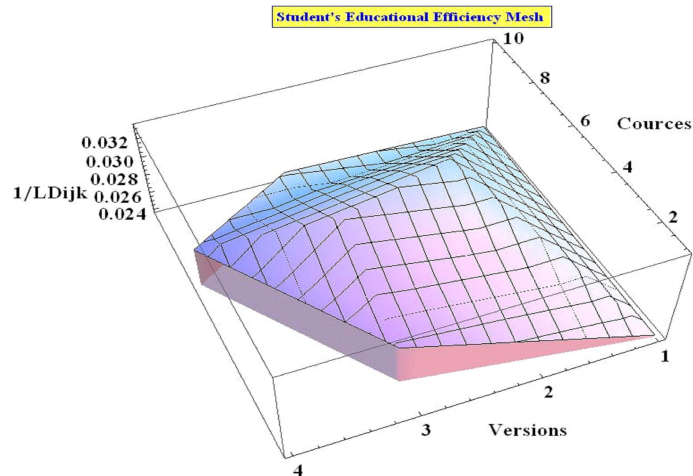
Fig. 2. Course versions in which the student k will have most learning difficulties

an apriori assessment of the effectiveness and for transformation of the existing e-learning content towards the individual student's expectations. This approach is based on existing e-learning content (e-learning modules), which is assessed with a definite system of criteria for acquiring the content important for the personalization – E-modules metadata. From the point of view of the models for data presentation, it could be accepted that each course is presented by a metadata structure.

The choice of the structure and the content of the metadata is based on the idea that each module can be described according the personalization needs and the presented metadata content must be understandable for the experts who will process the courses in Stage 1 from the presented approach (Fig. 3).

One example of a metadata structure for presenting e-learning module is shown in Table 1. The structure presented in Table 1 is an example and aims at visualization of the formalization level by metadata. The experts' task is to assess the proportion of the learning modalities that each course offers and thus to define to which learning style it is most appropriate.

The last three elements from the metadata structure have a direct connection with the learning styles and the 3D model (stage 4 from the presented approach). At stage 2 of the approach a questionnaire is offered to the students in order to define for student j his personal style of learning, presented in the approach by the data structure SLP ID$_j$ (Fig. 3).

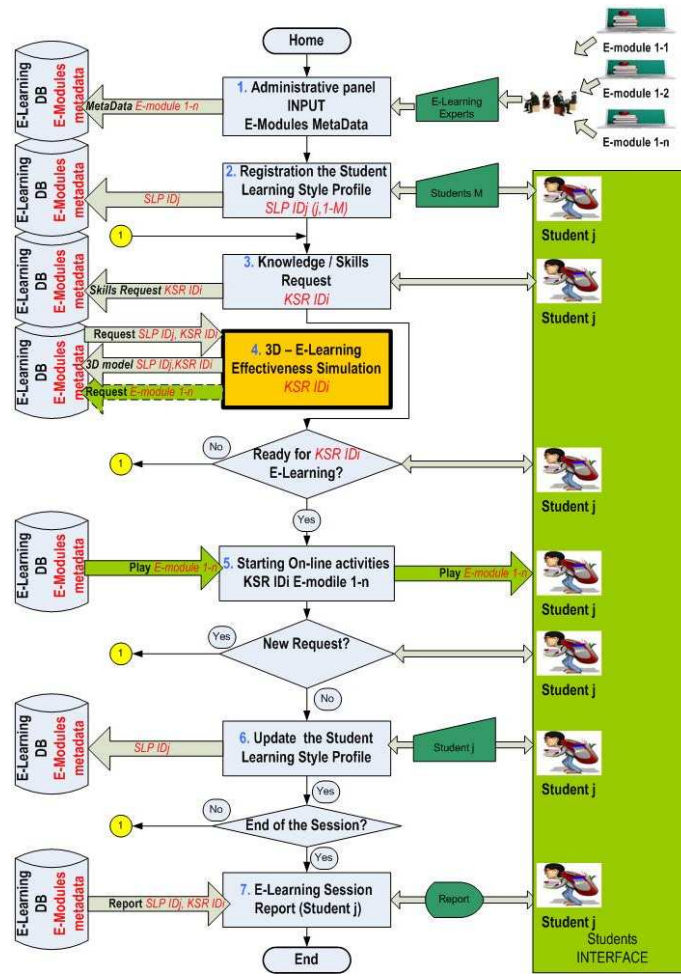Table 2 shows the content of the data structure SLP ID$_j$, which presents

Fig. 3. Flowchart of an approach for e-learning personalization

the profile of student j, $j + 1$, $j + 2$.

The results in Table 2 presented the application of the structure for formalization of the learning content by metadata. In this way informational support of the 3D simulator for assessment of the effectiveness of e-learning (Stage 4 of the approach) is ensured, based and developed on the basis of the 3D model

The data structure (Stage 3) KSR ID$_i$ is used for formalization of the students' request for e-learning content. For good quality of applying the experimental approach, it is necessary for the personalization of the e-learning to assess

Table 1. Example of Metadata structure for describing e-learning module

Metadata structure	E-module $1-n_1$	E-module $2-n_2$	E-module $3-n_3$
Field of science			
Subject	1–"…."	2–"…."	3–"…."
Date of creation	12.05.2010	17.05.2010	21.02.2010
Language (s)	EN,BG	EN	BG
Author	"………….."	"………….."	"………….."
Average duration (hours)	0,8	1,2	0,9
Learning by seeing in % from the whole learning process	70%	20%	50%
Learning by hearing in % from the whole learning process	20%	50%	20%
Learning by doing in % from the whole learning process	10%	30%	30%

Table 2. Example of metadata structure for presenting a student's profile

Data structure for presenting students' profile for students j, $j+1$, $j+2$	Student j	Student $j+1$	Student $j+2$
Name of the student	"…………"	"…………"	"…………"
ID	XXXX	YYYY	ZZZZ
1st preferred language	BG	BG	EN
2nd preferred language	EN	EN	RUS
3rd preferred language	RUS	RUS	BG
Effectiveness of acquiring knowledge by "seeing" in %	70%	20%	50%
Effectiveness of acquiring knowledge by "hearing" in %	20%	50%	20%
Effectiveness of acquiring knowledge by "doing" in %	10%	30%	30%

not only the personal learning style of the students, but also their individual needs for learning (Table 3).

Table 3. Example of formalization of the students' request for e-learning content

Data structure for presenting the individual requests of student j, $j+1$, $j+2$	E-module $1 - n_1$	E-module $2 - n_2$	E-module $3 - n_3$
Name of the student	"..........."	"............"	"..........."
ID	XXXX	YYYY	ZZZZ
Field of science	"..."	"..."	"..."
Subject	1–"..."	2–"..."	3–"..."
Expected average duration (hours)	1,5	2,0	2,0
Actuality of the content – published no later than – data	01.01.2010	01.01.2010	01.01.2010

The output information for applying the 3D model as a tool for e-learning effectiveness assessment is formed on the basis of the data structure from Tables 1, 2, 3. The information from Stages 1, 2, 3 according to Fig. 1 is stored in a database–E-Learning DB.

The 3D simulator for e-learning effectiveness assessment (Stage 4) is based and developed according to the 3D model of e-learning. The input data for the simulator is the student's request KSR ID_i and the profile of student j, SLP ID_j. In the concrete example we assess all N courses with subject "1–...", which are described with metadata in E-Learning DB–E-Module 1–1, E-Module 1–2, E-Module 1–N.

At stage 5 the most effective e-learning module according to the individual student's learning style and needs is offered and the real learning process is conducted. Upon finishing the learning session in the experimental approach there is an opportunity for new testing of the student – Stage 6. The actualization of the student's profile gives a possibility for feedback after finishing the course. In the experimental approach this feedback is not directed towards assessment of the e-learning content or the way of presenting the material, but towards improving the student's self assessment about his preferred learning style. In this way one of the basic disadvantages in the presented approach – the formation of the learning styles by self assessment is not always subjective. With each module the

student corrects the proportion of the three perceptual modalities in his individual profile. The presented experimental approach for applying the 3D model for assessment of the effectiveness of e-learning is not only important for presenting and applying the 3D model, but it also has methodical value, according to the idea for dynamic adjustment of the individual learning profile of each student with the aim of increasing the personalization level in the e-learning process.

4. Conclusion. On the basis of the suggested new 3D model for e-learning as a tool for increasing the effectiveness of the e-learning process and the new approach for management of this effectiveness, some additional investigations and developments could be provided. There are some actual future tasks:

— A module from a Web-based system for adaptation of the e-learning content to the individual student's learning style by applying the 3D model could be developed;

— A sub-module for actualization of the students' learning profile after finishing a course could be developed. This will increase the effectiveness of the learning, because it will guarantee actuality and higher adaptiveness of the e-learning system.

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