

# II. THEORETICAL AND METHODOLOGICAL ANALYSIS OF DISTANCE LEARNING

## PERSONALISED EDUCATION THEORY

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***Abstract:** The article describes a new form of e-learning – adaptive e-learning. The theory of this form is based on a series of pedagogical-psychological rules which are aimed at technical possibilities of today’s IT. The very basics of adaptive e-learning is comprised of the student’s learning style and a group of algorithms which will assign the suitable study material to a student according to his/her learning style. This whole process is automatized and secured by a virtual teacher – control manager. Its functions will be described in detail in this article.*

**Keyword:** individualization, adaptive teaching process, e-learning environment, adaptive study aids

### INTRODUCTION

The term personalisation covers the adaptation of solution of various problems, situations and environments ... to specific conditions and requirements of individuals. Areas in which we can come across personalisation are numerous: advertising, web pages, ZOOs, museums, education, etc. Personalisation usually comprises three basic parts – for whom, what and in which manner. Let us focus on the personalisation of education.

One of the modern forms of education is e-learning. It is used in the simplest forms (presentation of study materials in PDF files on web pages), but also by using modern informatics systems that manage the education and many follow-up activities of the teacher and student (Learning Management System – LMS). Both of these classic examples do not take into account the specifics of individual students, i.e. not taking their learning preferences into account – learning style, abilities, characteristics, knowledge, requirements.

If we consider the time-proven pedagogical-psychological theories of education and today's possibilities of information technologies, we can try to create an education process tailored to the preferences and requirements of an individual. Attempts to individualise education have occurred in the past. Most of them remained, due to technical limitations, in the theoretical realm; they have not been practically realised. Today, with suitable technical equipment and possibilities, the situation is more favourable. We will try to create conditions for individualised personalised education in the environment of electronic learning.

Improvement of education via adaptive e-learning education should be visible in two levels. The first level is the acceleration of knowledge gain. The second level is more natural way of studying for every student thanks to taking individual characteristics of students into account. Optimal adaptive procedure should respect differences between students based on identified learning style with consideration to the changing knowledge and skills of a student during course. Based on the identification of personal characteristics and attributes there will be a studying material handled in a form that matches a student as much as it can. Adaptive form of education is the recently often mentioned area, but not fully explored and practically unrealized yet.

## **1. PEDAGOGICAL BASIS FOR ADAPTIVE EDUCATION**

In connection with education of pupils, basic didactic principles that concern individual approach must be reflected. The principles are rooted in personality psychology. They presuppose that every student is an individual and should be approached as such. By looking at the definition closer, it can be deduced that faster learning students should be taken into account as well as the slower ones. However, how can one secure optimal education that takes into account personal and other characteristics of students? If we take education done by the real teacher, only their pedagogical mastery affect how well they are able to manage a group of different students. Individual education with just one student can be an alternative to group teaching or teaching in class. When assessing student's characteristics it is important to consider the optimal mediation of curriculum in order to provide as comprehensive knowledge and abilities as possible. This can be secured by personalised education that is adapted for a specific person – the student. Education adaptation can be characterised as a change in the way of teaching the same curriculum; always in a different way that is most suitable for the needs of specific students. This is hardly achievable in classic classroom education, but possible in computer aided and managed education.

The theory of adaptive e-learning (Kostolányová 2012) is based – besides the already mentioned principle of individually – on other theories of renowned pedagogues and psychologists – Komenský, Gagné, Bloom, Kolb, Tollinger, etc. (Tollingerová 1977, Gagné 1975). Terms such as training, education, teaching and learning appear in the works of great authors of various nationalities. The theory

of adaptive education follows up their terminology and expands it to suit today's conditions and possibilities of electronic education.

In our personalisation design, the most important aspect is to define the term learning style. It is this type of characteristics of an individual that will serve as the basis for the education adaptation and personalisation. The classification of learning styles is the focal point of work and research of many authors. They examined various characteristics of students that are connected with learning and used them to divide students into student types. For our purposes, a learning style is a set of student's characteristics that can be taken into account in e-learning and define the learning style of each individual.

The adaptive e-learning education theory is based on the principle of programmed teaching, adaptive hypermedial systems and principles of Gagné's event education. The adaptive education theory shares a basic principle with programmed teaching (Tollingerová 1977): Dividing curriculum into small units, a verification of these small units and a reaction of educational system to student's understanding of the curriculum. From the adaptive hypermedial systems (AHA) (Brusilovský 2001, 2005), whose essence is a reaction to user's behaviour and control of his movement in the system, the adaptive e-learning theory takes monitoring of the student (we further mention logging of education process) and feedback implementation. Gagné's theory gave origins to the structure of adaptive study material (see below) (Kostolányová 2012).

## **2. DESIGN OF ADAPTIVE EDUCATION MODEL**

Taking into consideration the theoretical foundations of personalisation in general, the system of adaptive education is divided into three parts – area for which we prepare personalisation, area in which we create personalisation and mechanism that is used for its practical execution.

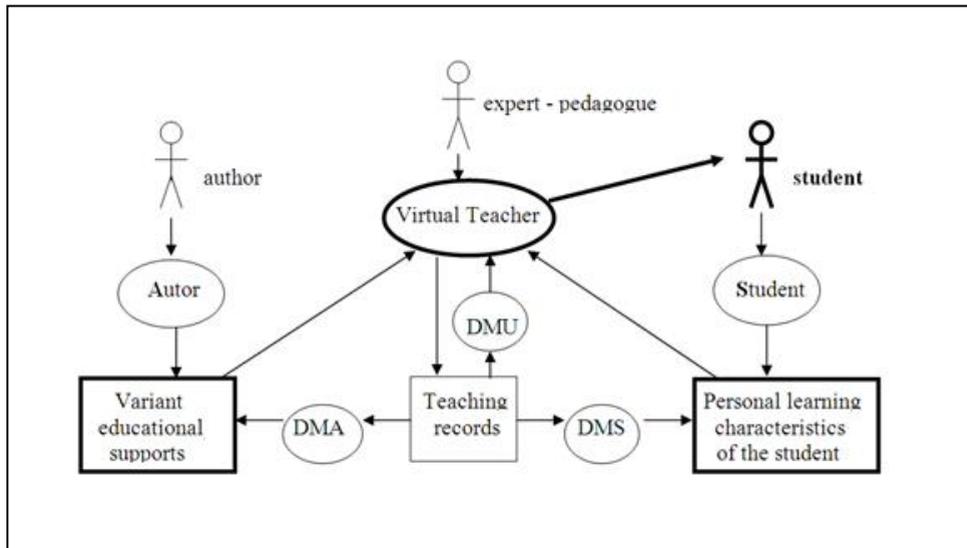
The theoretical model of adaptive e-learning can be seen in figure no. 1 (Kostolányová, Takács, Šarmanová, 2011a). The system comprises 3 parts – student module, author module and virtual teacher module.

The system has been divided into three parts from the practical point of view:

- student's learning characteristics diagnosis, current education and testing of students (student module),
- structuring educational supports, creating methods for the making of adaptive studying materials (author module),
- design of adaptive algorithms for the optimal formation of customized learning environment (virtual teacher module) and recording the education process

Each part deals with several sub-problems:

- In order to react to different learning characteristics of students, the controlling educational software must know student's information, the ones which influences the learning process. All of which are they?
- How to get information about student's learning characteristics?
- How should educational support material look like to be able to adapt to student's learning characteristics?
- How should the teacher (virtual) teach each type of student?
- These problems are solved within each module of the adaptive education system (Kostolányová 2013).



**Figure 1. Adaptive education model diagram.**

Source: Kostolányová, Šarmanová and Takács, 2012; Kostolányová, 2012

## 2.1 Student module

After the completion of extensive background research and analysis of available publications on the issues of learning styles (Kostolányová 2010), characteristics that define the learning style of the student and that can be affected in the e-learning form of education (e.g. *sensory perception, social aspects, affective aspects, learning tactics, etc.*) have been selected. Values of these characteristics that define the learning style of the student are discovered by a custom tailored questionnaire.

## 2.2 Author module

The author module is used for preparing, saving, and maintaining adaptive study materials. To divide the study aid we use the common way of dividing textbooks into chapters and subchapters. Considering the adaptability possibilities we further

divided the curriculum into the so-called **frames** – they represent a fractional unit of information (in a typical textbook this would be one term). Furthermore, we know that teaching methods comprise the sequence of elementary learning steps – beginning of instruction, explanation, exercise, examination and finalisation. To be able to use this principle in the field of adaptable education, we separate the teaching process according to R. Gagné. We divide parts of frames into **layers**. There are three types of layers – instructional, testing and other. The instructional layer concerns the presentation of the curriculum – presentation, semantics, practising exercises, solved exercises, conclusion. Testing layers comprise exercises to be solved, questions and tests. Other layers include the motivational layer, the navigational layer and the layer with extending resources. These parts of the study aid are prepared for four sensory variants (verbal, visual, auditive and kinaesthetic) and in three depths of complexity of the curriculum (average, more comprehensive – slower instruction and more comprehensive – enriched with additional information and interesting facts).

### 2.3 Virtual teacher module

Suitable form of the education process is understood as a suitably sequenced study material (as far as its parts are concerned). The managing programme that structures education and controls its comprehension is called the **virtual teacher**. This expert system covers several functions:

- Looks for the registered student's **learning style** (LS), i.e. characteristics that affect their learning. To this learning style it assigns **personal education style** (PES), i.e. the procedure that will suit the student the most (sequencing of individual parts of the study material in terms of the layer type and its sensory and depth variants).
- In a real, actual study material, some variants may not exist and some frames may not utilise all types of layers. Therefore the next step of the virtual teacher is to apply the personal education style of the student to the actual study material, i.e. to determine the **actual education style of the lecture**. The result of this is a specific sequence of layers and their depths.
- Based on the optimal AES plan of passing the lecture, the virtual teacher manages the education process, i.e. successively presents the frames and selected layers of certain depths and sensory variants to the student.
- Another issue that the virtual teacher needs to deal with is the **reaction of the system to erroneous answers** of the student. If the student answers to control questions and exercises correctly, they progress in accordance with the actual education style. However, if the student answers incorrectly, the situation must be solved in a suitable way, in the context of the given situation.
- The last function of the virtual teacher is to record the whole education process to allow for the analysis of all the situations and to gain feedback

concerning the correctness of student's characteristics, to verify the suitability of the study aids and to double check the correctness of the expert rules of the virtual teacher.

### 3. FORMAL STRUCTURE OF ADAPTIVE RULES AND ITS VERIFICATION

To determine the theoretically optimal personal education style for a specific student means to choose the most suitable sensory variant and add the optimal sequence of layer types and depths for each frame (complete in theory; with all types of layers). This variant and sequence of layers in it is used universally for each frame of the lecture.

Personal sensory variant of the student is defined by the most prolific type of their sensory perception, i.e. the form with the highest value out of verbal, visual, auditive or kinaesthetic perception. For other characteristics we form elementary rules of general format:

If the student has characteristics  $V1=a$  and  $V2=b$ ,

then use layer sequence and depth  $X, Y, Z, \dots$ )

where  $X, Y, Z \dots$  individual layers (theoretic, semantic, ...)

$V1, V2 \dots$  characteristics of the learning style (motivation, self-regulation, ...)

$a, b, \dots$  values of these characteristics..

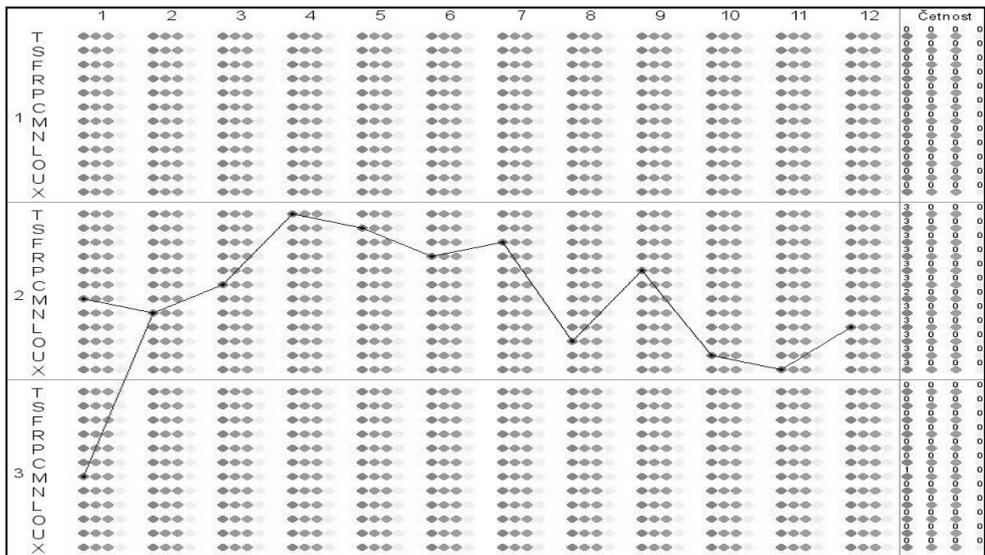
Rules assigning the sequence and depth of layers when displaying the frame stem from the static and dynamic characteristics of the student. They are ruled by expert rules created by an expert – pedagogue and expert on adaptive education. There are many of these “elementary” rules – for each value of each characteristic, or even some of their combinations.

Let us contemplate the content of the mentioned rules. We already stated that they are expert pedagogical-psychological rules on how to teach a specific student with the defined learning characteristics. The content of these rules is the most demanding professional part of the whole theory of adaptive education. It cannot be expected that these rules will be ideally defined from the very beginning. They will have to be fine-tuned – on the basis of further research activities.

The first step to testing the designed rules is to verify their correct function by modelling the education process. To fully fine-tune the first three functions of the virtual teacher (creating the model, followed by simulating the recommended way of teaching) we need to define all basic types of virtual students and all variants and layers of the teaching aid.

We assign the virtual students with learning characteristics. By combining their values (working with 2–4 values for each characteristic) we arrive at 2,000 possible types of students. We simulate the education for these individual types or groups with one or more identical values. We model the virtual teaching aid using only their metadata.

After finishing the research and analysis of modelling tools (Balogh, Z., 2011; 2012) we decided to create our own modelling tool that would best suit our needs. The tool uses the already mentioned expert rules and algorithms to determine the personal education style and actual education style. It can visualise passing through the study material for different types of students and thus enable the inspection of their education styles. It also provides data for the analysis of the frequency of the passing through individual parts of the study aid. Special method of visualisation of the results of PES and AES displays a pattern of all theoretical variants of one frame (sensory perception and depth of instruction) with all possible layers. Into this pattern it can draw the progress recommended by the virtual teacher in the form of polygonal chain that connects individual layers in the recommended sequence and depth (Figure 2). We call this diagram a trace of adaptive education process, education trace in short. Each trace corresponds with one education style for one type of student.



**Figure 2. Trace of Adaptive Education Process**

*Source: Kostolányová, 2013*

#### 4. MODELLING THE PROCESS OF ADAPTIVE EDUCATION

For pilot modelling of the education process we test elementary rules at first; for this reason individual characteristics are added to modelling gradually, not all at once. Selected characteristics were motivation, learning concept, depth of study, self-regulation and success rate. Values of individual characteristics are usually set to three values – minimum, average and maximum (0, 50, 100 or -100, 0, 100).

To model the functionality and correctness of all elementary rules we use a complete study aid (represented by metadata) with no variants or layers missing.

Procedure of modelling individual elementary rules:

- Simulation of teaching a student “average” in all characteristics (their PES should correspond with the “classic” way of teaching used in most textbooks);
- Simulation of teaching with the change of the tested characteristic to high and low; verification of the functionality and correctness of designed expert rules. This approach is first tested with one student and then with a group of students having the given value of examined characteristic and other characteristics being average;
- If the resulting diagram does not correspond with the expert’s notion of PES, an error is noted down (incorrectly formulated expert rule or incorrect function of the PEStyl algorithm).

Using the same modelling tool, it is verified if the rules are correctly designed for the case when it is necessary to combine several rules that correspond with different student characteristics. At first combinations of two, then three and finally four characteristics were tested in all possible variants. E.g. for two characteristics – motivation and self-regulation – these combinations were tested: average values of motivation and self-regulation; low motivation and high self-regulation; high motivation and low self-regulation, etc.

In the second phase of modelling, functionality and correctness of the AEStyl algorithm were tested. In real-life education VT does not have an ideal study aid, which would always have all layers in every variant of instruction. For this reason we focused on the use of suitable substitute variants and layers of the study material, for situations in which the theoretically complete study aid is not available.

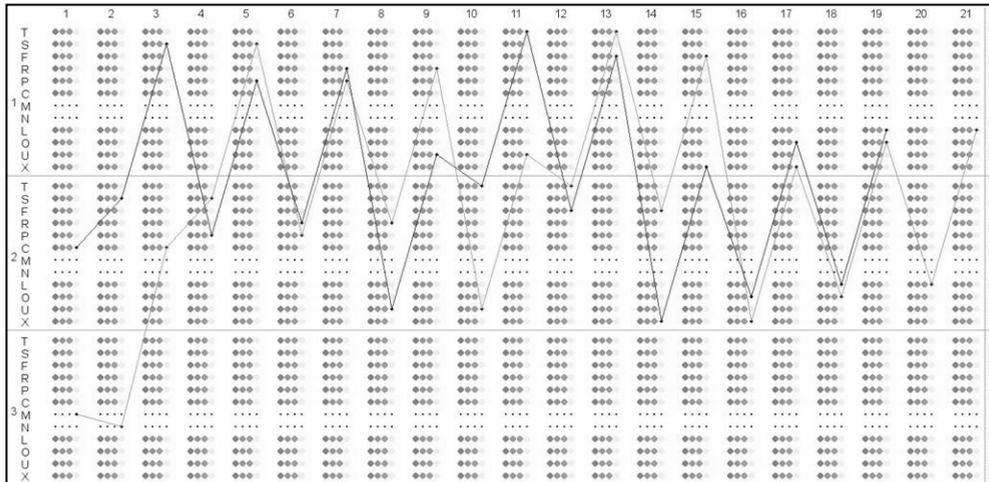
In the AEStyl determining algorithm it was necessary to map the situation of existing variants and layers and solve the situation in case of absence of some of them: substitute the missing layer with a “closest related” one, if such exists, or omit it altogether if it is not available in any other version.

In the pattern, the missing parts will be marked only by a small black dot; existing layers of corresponding variants are coloured (see for example Figure 3).

The experiments verified many correctly realised substitutions or leave-outs except for the following:

- when substituting a missing layer both were displayed; the original was incorrectly duplicated instead of replaced;
- in case of missing preferred sensory variant this was substituted by any other sensory variant instead of the second most preferred variant.

During the simulation of the education process some mistakes have been discovered (see more in Kostolányová 2013) and corrected.



**Figure 3. Progression through Incomplete Study Aid**

*Source: Kostolányová, 2013*

## CONCLUSION

Today, e-learning in its classic form is almost obsolete. Personalisation, individualisation and student's tailored education has gained prominence and piqued the interest of numerous experts. The theory of personalised education as mentioned above is the basis for its gradual practical realisation.

Based on the analysis, the created adaptive LMS Barborka was implemented and tested. In the new theory – on the basis of practical testing in real education – there will be modifications concerning both student's characteristics and the managing rules of the virtual teacher. The collective authors of this idea believe that their efforts and endeavours will be rewarded in future in the form of modern, optimal and interesting way of learning.

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