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Theoretic Principles of the Adaptive Teaching Process

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 the 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 a suitable study material to the 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.

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

Introduction

It is known from the classic teaching that some school students might be hindered by and bored with collective teaching. Other ones, on the other hand, might find it too fast so, as a result, they might not be able to understand everything. Other students are satisfied with the teaching pace, but may not be satisfied with the teaching style of a particular teacher. Consequently, such students dislike some teachers and courses and their academic achievement might become worse (Vališová, Kracíková, 2011).

Those reasons lead to the idea of the optimization of the learning process through the individualization of teaching. The individualization of teaching mirrors the already gained knowledge, skills, and learning style in the learning process of each student. Such a method cannot be applied in typical face-to-face classes where the student cannot be treated individually. The teacher can adjust their teaching style

to suit the majority of the students in the class. However, the teacher cannot adjust teaching to suit every student in the class individually.

In the information age, the Internet, or suitable SW and HW instruments, it is no problem to implement the use of computers for teaching, especially through e-learning. E-learning is most frequently done through the LMS (Learning Management System). In the current frequently used LMS the student's role is passive, hardly ever active. The student often does not have a chance to influence the study process which he/she is part of. In the literature there are several recommendations, rules, and theories that are aimed at better and easier learning. Those generalizations, however, suppress the individuality of particular students. The used theories are in many cases based only on the student's already gained knowledge and do not pay attention to his/her individual learning needs that could help him/her understand particular information in a more effective way.

By connecting e-learning with the requirements of the personalized teaching we come to the term automatic adaptive e-learning. We asked ourselves a question if the procedure of automatic adaptive e-learning can be modeled (i.e. passing an e-study course which suits the student's preferences and his/her learning style). The best adaptive way to do it will be by respecting the differences among students based on the observed learning style and with attention paid to the student's changing knowledge and skills throughout the course. The students will be provided with the study material that should suit their needs best. The material will be based on the identification of the personal characteristics and qualities.

We think that teaching prepared to suit the student's needs and preferences with the emphasis on the positive aspects of learning will become the best and most effective teaching method. It will help in achieving easier and more permanent learning and storing of knowledge. Our goal is to create a user friendly e-learning environment, which will be adapted to the user according to the given learning preferences.

1. Pedagogical- Didactic Solutions for Adaptive Teaching

Many pedagogical-didactic principles, rules and theories were used as **theoretical solutions** while formulating the theory of adaptive teaching. These include:
- Komenský's approach to teaching
- Gagné's approach of eventful teaching
- Bloom's taxonomy of education aims
- Skinner's theory of programmed learning

To achieve a successful and effective learning process it is necessary to follow the basic principles coined by J.A. Komenský (1947, 1948) – orderliness and steadiness, gradual explanation, appropriateness and permanency of knowledge and skills. The teaching process can be understood as the succession of elementary steps in learning to which there is a defined order (Gagné, 1975). The sequence of events should have the following order – attracting attention, formulating aims, drawing on previous knowledge, presenting new information, guiding and encouraging students, giving feedback, rating the student's performance and ensuring storing of acquired information. The hierarchy of the particular activities, through which the student goes throughout the learning process and which are graded by difficulty, comprehensiveness, and requirements of the studied material, was created by D. Bloom (Tollingerová, 1977). There are six most frequently mentioned degrees of knowledge – remember, understand, apply, analyze, synthesize, and rate information.

With regard to the environment in which teaching should take place, principles reflecting the theory of programmed learning (Tollingerová, 1977) and the basics of adaptive hypermedia systems have been added to those pedagogical principles. The fundamental idea has been taken from the theory of programmed learning: dividing information into smaller units, verifying these smaller units and the reaction of the education system to the student's understanding of the subject matter. The programmed learning deals only with the reaction of the system to the student's correct or incorrect answers. By branching the teaching process into different ways, the author – teacher himself controls (programs) teaching.

The observation of the student (we will mention the recording of the teaching process below) and feedback realization is taken from the idea of the adaptive hypermedia systems (AHS) (Brusilovský, 2001, 2005), which are based on the reaction to the user's retrospective behavior and movement in the system. Out of several kinds of adaptation (Kostolányová, 2012), the model discussed in this article deals with the adaptation of the teaching content – particularly with the adaptation of the study material according to the students' individual needs.

Today the use of the electronic environment for teaching is natural. The abovementioned basic ideas enhanced by a new form, i.e. adaptive teaching, will be implemented in this exact form of teaching environment – adaptive e-learning environment. We can look at the student who learns with the use of the computer as an individual and subsequently prepare teaching according to his/her individual qualities. This cannot be achieved in the typical class with typical face-to-face teaching. Finally, the proposed adaptive system should secure and enable an individual and personalized way of teaching of any number of students according to their individual qualities and knowledge.

2. Practical Solution

Practically, the problem of **formulation of adaptive** teaching was divided into three tasks:

- Determining and diagnosing the student's learning characteristics,
- Structuralizing teaching aids, creating the methodology for the elaboration of adaptive teaching aids,
- Proposing adaptive algorithms for forming the best personalized teaching.

When formulating the theory of adaptive teaching, those three parts were further divided into problems that are gradually being dealt with:

Problem 1: To be able to react to the student's various learning characteristics, the teaching control manager must have the information about the student that has an impact on his/her learning process. What is this information?

Problem 2: How to acquire information about the student's learning characteristics?

Problem 3: What must the teaching aid be like if it is to be adapted to the student's learning characteristics?

Problem 4: How should the (virtual) teacher teach a student of a particular type?

3. The Student's Learning Style

The question of learning styles, their detailed background research, analyses and evaluation of pilot questionnaires, was published in Kostolányová, Takács, Šarmanová (2011a). To ensure the complexity of the view of the methodology of adaptive teaching preparation, only the findings of detailed analyses will be mentioned here.

The main person of the adaptive teaching model is the student, for whose education the entire system is being created. In order to secure that the system can react individually to the student's current knowledge and learning characteristics, we need to have a lot of information about the student. These qualities need to be stored in a student database.

A detailed analysis of the pedagogical-psychological literature on learning styles has proved that no classification of learning styles reflecting the student's characteristics that could have an impact on his/her learning style has been made yet. The following group of the observed qualities is the result of our research and analyses (Kostolányová, 2012):

sensory perception – sensory variants: verbal, visual, auditory, or kinaesthetic

social aspects – the student studies alone – in a pair – in a team

affective aspects – motivation for studying

learning tactics – orderliness, the way of information processing, conception of the subject matter, learning process

self-regulation – the student acts on advice – by him/herself

success of ongoing studies – is connected to continual testing and filing of the student's academic achievement.

This solved problem 1 – the information impacting on the learning process has been determined. To secure solving of problem 2 – to find out the student's individual characteristics, a questionnaire was designed (after a not too successful attempt to use the already existing questionnaires by various authors) to suit these characteristics.

4. Adaptive Teaching Aid Structure

Another task (Problem 3), which was being solved and became part of the theoretical basis for adaptive teaching modeling, is the suggestion of the teaching aids structure (Kostolányová, Takács, Šarmanová, 2011b). The following considerations led to the suggestion of the solution.

The common way of the textbook division into chapters and subchapters was used when dividing the teaching aid. Considering the possibilities of the adaptability of the teaching material and formulating the methodology for creating these adaptive study materials, we were inspired by the methodology of creating distance study materials, the principles of programmed learning and the above-mentioned principles of the pedagogues like Komenský, Gagné, and others.

To be able to adapt to students various personalities, the teaching control manager (virtual teacher) must have the subject matter processed in many different ways. The subject matter must be in a structured form – the subject is divided into chapters, subchapters, and paragraphs. The smallest compact part that presents a unit of information is called a **frame**. Objectively, the frame corresponds, for instance, to a newly established term (term definition, term explanation, application, example verifying testing questions and tasks). On a formal level, the frame usually corresponds to the lowest level of numbered or in other way marked paragraphs in the text or on the internet site, including particular multimedia components (Kostolányová, Takács, Šarmanová, 2011a).

In terms of the different forms of sensory perception, the frame needs to be elaborated in **4 sensory variants** (verbal, visual, auditory, and kinaesthetic). In

terms of the student's understanding or his/her success in the continual questions, we suggested that 3 other explanation variants, which differ in the amount of details, be used. We call the three mentioned levels the **depth** of explanation. As there are 3 variants for each of the sensory forms, there can be as many as 12 explanation variants for one frame. By so doing we reacted to the first four sensory forms and to the last characteristics – the success of the student's learning style.

It is clear that we cannot go on "reproducing" the variants for the remaining 9 characteristics. Carrying out the adaptation of the frame explanation style will enable us to divide the frame into two parts – **layers**. The layer of the frame is a part of it that is homogenous in terms of the teaching process phases (theory explanation, fixation, knowledge testing, motivation, teaching process controlling) (Kostolányová, Takács, Šarmanová, 2010).

We suggested the following types of layers:

- *Explanatory* – a group of layers that contains the explanation of the subject matter itself (theoretical layer), explanatory layer (semantic), revision (fixation layer), layers of the solved school and practice examples.
- *Testing* – a group of layers for the continual testing of acquired knowledge. It is made of questions, school tasks, and practice tasks.
- *Other* – aims, motivation layer, navigation layer, and literature layer.

We will react to the values of the other chosen learning style qualities by combining the order of particular layers in a different way. The suggested structure of the adaptive study material is a solution to the following problem: What must the teaching aid be like if it is to be adapted to the (learning) type of the student? (Kostolányová, 2011).

5. Virtual Teacher, Personalized Teaching Process Controlling

We are familiar with the set of the student's qualities that characterize his/ her learning style. We know how to find out their values and thus determine the student's learning style. We have teaching aids at our disposal that are able to adapt in an arbitrary way according to the student's needs. We have to solve another and the most important problem: *How should the (virtual) teacher teach a student of a particular type?* (problem 4).

The teaching process controlling is very demanding. Moreover, the author and the teacher cannot see it. It will be the student to whom the subject matter will be explained in a different way from other students. We call the control manager,

which compiles the teaching process and tests its understanding, a **virtual teacher**. Gradually, this virtual teacher has to do the following tasks for every student:

1. It determines the student's **learning style (LS)** – the characteristics that influence his/her learning process – for each logged in student.
2. It determines the student's **personal education style (PES)** – a process that suits the particular student the most – for his/her learning style. An ideal personal education style does not have to be valid for every real frame of the teaching aid to the same degree. There do not have to be certain variants in the actual lesson. Some frames do not have to use all types of layers.
3. It applies the PES to the actual lesson, i.e. determines the **actual education style (AES)** of the lesson.
4. Knowing the ideal plan of the AES lesson process, the virtual teacher controls the teaching process, i.e. it offers the student frames and layers, depths and sensory forms that were chosen from those frames.
5. Another problem the virtual teacher has to deal with is **controlling the reaction of the system to the student's incorrect answers**. If the student answers the questions correctly, it follows the pattern of the actual education style. However, if the student answers incorrectly, a suitable solution must be found in accordance with the context of the actual situation.
6. Education process recording.

5.1. Adaptive rules formal structure

To determine the ideal learning style for every student means to choose the most suitable sensory variant and to determine the ideal sequence of types of layers and depth for every (theoretically complete – having all types of layers) frame. This variant (together with the sequence of layers in it) will be used for every lesson frame.

The student's personal sensory variant is defined with respect to the most visible type of sensory perception:

$$OStForm = maximum\ value\ form\ of\ (Sver, Sviz, Saud, Skin)$$

For the remaining characteristics we formulate elementary rules of the universal shape:

If the student has the qualities Q1=a and Q2=b at the same time, use the X, Y, Z… sequence of types of layers and depth

Where

X, Y, Z… are particular layers (theoretical, semantic…)

Q1, Q2… are learning style characteristics (motivation, self-regulation…)

a, b, … are values of the given characteristics

The rules assigning the sequence and depth of a layer are expert rules set by an

expert – pedagogue and adaptive teaching expert. There are many of such "elementary" rules – for every value of every quality or for some of its combinations.

5.2. Content of adaptive teaching pedagogical rules

The content of the rules is the most demanding part of the entire theory of adaptive teaching. It cannot be expected that the rules will be defined in the best way from the very beginning. They will have to be gradually modified, based on the results of further research.

Formulation of some rules:

- Basic depth-variant is 2. If the student has the Success quality = 3, then, when dealing with the explanatory and testing layers, depth 2 must be used first and depth 3 next. If the student has the Success quality = 1, then, when dealing with the explanatory and testing layers, depth 2 must be used first and depth 1 next.
- If the student has the Conception quality = 75 (depth type), then depths 2 and 3 must be used in the order determined by other rules.
- If the student has the Motivation quality = 75 (very motivated), then insert the depth 1 motivation layer; if it is not present, leave it out completely.
- If the student has the Self-regulation quality =-50 (very dependent), then insert the depth 3 navigation layer (list of the detailed pedagogical study advice).
- If the student has both the Theoretician quality = 25 and the Experimentalist quality = 75 (practical type), then use the following order of the layers: S (semantic), P (practical), F (fixative), U (tasks), X (practice tasks), T (theory), Q (control questions). In other words – first, explain the new subject matter and give examples. Then verify its use. Then describe the theory and verify the knowledge of it.
- etc.

The formulation of these basic rules has been suggested with regard to the pedagogical experience of the experts. They are not always supported by a pedagogical or psychological theory. However, they represent the foundation for the creation and formulation of other rules which will be based on gradual analyses, teaching evaluation and by continual testing mechanisms. The rules will contain the defined principles and conditions of a **good teaching style,** which should make even the students with incorrect study habits use more appropriate learning methods offered to them.

We can see that there are several types of rules with regard to their use in the entire sequence of layers. Some rules have to carry the information that some layer should be placed before or after other listed layers. Other rules, on the other hand, only have the explicitly stated sequence of layers. In some cases only the

depth needs to be determined for the rule, regardless of the sequence of layers. Another type of a rule is used for noting the sequence of layers in the case of a multilayer. Some rules have to be applied before other rules; the sequence has to be determined. Finally, some rules define the creation of the entire lesson pre-frame or post-frame with the recommended content.

To be able to distinguish these types, other parameters are being added to the rules. These will not be listed here as they represent a technical solution to the formulation of the rules and their subsequent use in the PES construction algorithm.

5.3. The student's personal education style

From the elementary rules the specially developed expert algorithm will compile a complete sequence of layers with its depth for a particular student.

Algorithm for the creation of a personal education style:

1. Determine the student's personal OStForm sensory variant as a form with the maximum value out of the four sensory variants (Sver – verbal perception, Sviz – visual perception, Saud – auditory perception, Skin – kinaesthetic perception).
2. For every examined student quality
    a. find its closest virtual value that can be found in the elementary rules LS → PES,
    b. find all the rules with the same quality value on the left side.
3. If there is an order to create pre-frame or post-frame in the actual rules, compile it by using the recommended rules.
4. Connect the found rules and compile the layer type order of the recommended depths.
    a. choose the rules that define the initial layers and place them, together with the depth, at the beginning,
    b. choose the rules that define the end layers and place them, together with the depth, at the end,
    c. choose the rules that only define the order of the layers and place them, in a given order, between the initial and end layers,
    d. in such layers where the preceding rules did not preset the depth, set it to level 2.
5. Define the personal education style of the actual PES student.

5.4. The student's actual education style

The compiled personal education style does not always have to be exercisable without changes. It is because there is the supposed existence of all variants and

all layers in every frame. That does not have to be true. The author of the aid can use only a limited list of layers in every frame. That is done in accordance with the teaching content of the frame. Therefore, before the start of teaching itself, the second step is the application of the PES to the chosen lesson. This results in the actual lesson learning style of a particular AES student.

The algorithm for determining the AES compares the structure of every chosen PES lesson frame. If any of the layer types of the required depth or sensory form is missing, it will use another available layer of the same type and of the closest depth and form. If the rule explicitly states that it should be left out if a given layer is missing, it is left out from the sequence. This fact results in the same sequence as in the PES, but this time repeatedly itemized for every frame of the actual lesson.

5.5. Teaching process controlled by virtual teacher

The basic task of the virtual teacher is to control the teaching process. That means offering students a given lesson, its sequence of frames and layers in the accounted order – according to the AES plan. If the student accepts the sequence determined by the system and answers the possible questions correctly, he/she follows the plan.

The following incidental situations can occur:

- The student finds any of the explained variants unsatisfactory (or he/she is only curious about another variant explanation) and chooses another variant. He/she can choose only the "neighboring" variants, i.e. to change the depth of the actual layer or to change the sensory variant of the actual layer. After he/she learns about it, the system returns the student to the initial layer of the actual variant. The student continues following the plan or he/she can choose another unplanned variant.

- The student chooses another frame, although the actual frame has not been finished. The system then "starts" passing through this frame; again according to the planned AES. If the student terminates passing through the lesson, the system will note which frames he/she already went through. If this is the way the student chooses the frame he/she has already visited, the system will continue teaching from the very point that the student left the frame at the last time.

- The student follows the plan, but he/she answers some of the test layers (question or task) incorrectly. In such a case the system activates the controlling algorithm that solves such a situation.

Conclusion

When creating the adaptive e-learning environment, the described theory is being gradually applied and tested. For this kind of teaching the LMS BARBORKA controlling system is being developed. The last of the virtual teacher's functions is recording of the entire teaching process. It records the student's every "click", the time spent on particular layers, not following the actions offered by the system, accuracy of answers, etc. The record is used for analyzing several types on a long-term basis: verification of the setting accuracy of the student's characteristics, verification of the appropriateness of the teaching aids as well as the verification of the accuracy of the virtual teacher expert rules.

As mentioned above, after collecting a large data sample in the adaptive teaching record, to be able to analyze the feedback we will use a series of mathematical statistical methods and methods of gaining knowledge from data. Research on this field has already started, but the already obtained results are not sufficiently reliable due to the low extent of the data. Next, we will focus on the research into the used methods as well as the interpretation of the analyzed results. At the same time, modeling of the adaptive teaching process through the virtual student (with all the combinations of the learning style qualities being defined) and virtual study materials (described by the metadata) is being carried out.

The modeling device is being implemented in the existing adaptive LMS. Before the teaching process starts, the modeling device verifies the accuracy of the elementary rules formulation and debugs the algorithms for their integration into the resulting personal learning style, i.e. the sequence and its depths.

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