Use of Adaptive Study Material in Education in E-learning Environment

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Abstract: Personalised education is a topical matter today and the impact of ICT on education has been covered extensively. The adaptation of education to various types of student is an issue of a vast number of papers presented at diverse conferences. The topic incorporates the fields of information technologies and eLearning, but in no small part also the field of pedagogy. By interconnecting eLearning with the requirement for personalized education, we obtain a new term – automatic adaptive learning. We asked ourselves a question if the process of automatic adaptive learning (i.e. going through the electronic study course which suits student's preferences and learning style) can be modeled. The optimal adaptive process will respect students' differences based on determined learning styles and with regard to their knowledge and skills as changed during the course. On the basis of identification of their personal characteristics and qualities, students will be presented with a study material which suits them the most. One of the basic building blocks of adaptive education is the storage of study materials. In order to be able to prepare tailored education for every type of student, study material must be prepared in many different variants, in different form. This form should be different from the classic form of text-books. This article presents the issues connected with the creation of study materials suitable for adaptive education in more detail; the basis for this is the pedagogical analysis of the starting prerequisites applicable in eLearning. In conclusion, a particular way of use of such created study material in electronic adaptive education will be outlined.

Keywords: study material, adaptation, learning style, creation of methodology, e-learning, personalization of education, theory of adaptive e-learning

1. Topic introduction and current status

Computers entered the education process in 1960s. Wave of modernisation brought the so-called programmed learning to education. The idea of managing teaching as process has been introduced, spawning a number of theoretical researches and practical experiments (Gagné, 1975). Many principles of informatics are often used for building education and teaching (e.g. linear programming, alternative programming, forked programming, adaptive programming, etc.) (Kolb, 1984; Tollingerová, 1966).

At the Department of Information and Communication Technologies (ICT) of the Pedagogical Faculty of University of Ostrava, under the research on education with the support of ICT (one of the main research directions of the University of Ostrava) we focused on the personalised education with ICT support.

There is increased interest in personalised education or education tailored exactly to one's needs, not only in lifelong learning (for extending or improving one's qualification, or simply out of interest), but also in all levels of school education (almost all pupils can access education through computer).

Publications (Průcha, 2002; Kalhous, Obst, 2009; Gardner, 1999) contain various recommendations, rules or theories that aim to improve and make learning easier. These generalizations, however, obscure the individualities of students. By interconnecting eLearning with the requirement of personalisation we arrive at the term adaptive education; i.e. education adapted to the current requirements, abilities and skills of the students.

Bibliographic search in Czech and foreign information sources (Brusilovsky, 2003a, 2003b; Őzpolat 2009; Peters, 2009) shows that the field of adaptive education is a current topic, but has only been worked on in partial tasks (adaptive navigation, adaptive presentation, creation of universal student's profile for various systems, adaptive selection of test questions, etc.). Besides purely pedagogical perspective, adaptive education is often mentioned in connection with information technologies. It is these technologies that take personalisation one step further and help in its practical execution.

New model of learning that should suit the individual needs of students is based on a new paradigm – personalisation of the education environment. The environment takes into account students' personal characteristics, their abilities and current knowledge, their learning style, etc. (Chang, 2009; Jeong, 2012).

2. Basic principles of adaptive education

In order for education to be adapted to specific student's characteristics, these characteristics must be known (diagnosis of static characteristics of the student) and have a suitably structured study material. Only then can the actual process of managed teaching begin. The whole system can be divided into three basic modules – Student module, Study Material module and Managing module. In the education process, these modules can be substituted by the student, study material and the teacher (Kostolányová, 2011a, 2011 b).

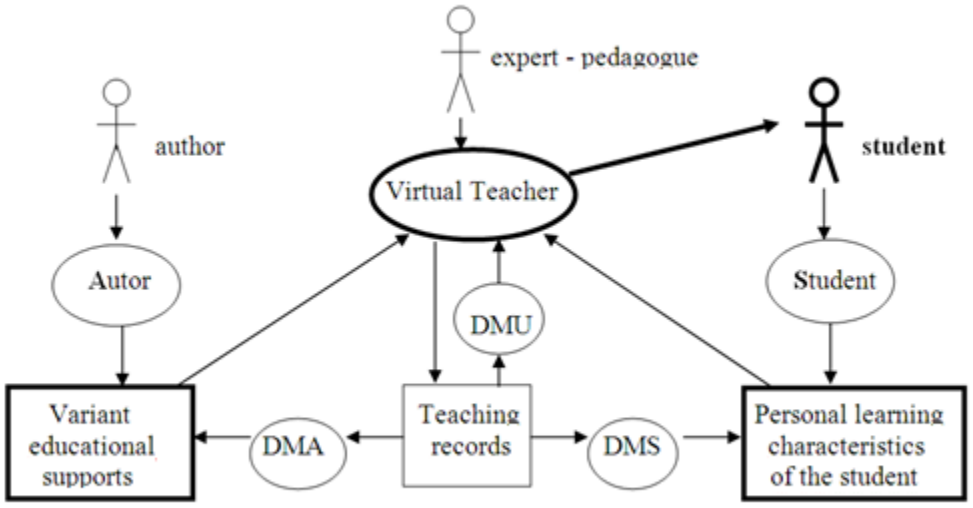

Figure 1: Theoretical model of adaptive education

To implement the idea mentioned above, a self-contained theory of individualised education must be created; one that includes the definition of the aggregate of typical independent students' characteristics (that impact the learning process), definition of the aggregate of teaching methods and styles (that can be used to react to specific characteristics of the student) and can assign optimum learning procedure for each learning characteristic.

The series of pedagogical-didactic principles, rules, and theories as well as practical experience from informatics became theoretical solutions for formulating the new theory of adaptive education, which influenced systematic view of individual parts of adaptive learning (Kostolányová, 2012). These principles are:

- Komenský's approach to teaching;
- Gagné's approach of eventful teaching;
- Bloom's taxonomy of educational objectives;
- theory of programmed learning;
- adaptive hypermedial systems.

For effective and successful learning process it is necessary to follow basic principles formulated by J.A. Komenský (Komenský, 2004; Kalista, 2009) – orderliness, systematic approach, continuous explanation, adequacy and permanency of knowledge and skills. The process of education can be viewed as succession of elementary steps of education for which there is a defined order (Gagné, 1975). The succession of events should have the following order: gain attention, formulate aims, pick up on previous knowledge, present new subject matter, guide and encourage students, give feedback, evaluate students' performance and ensure their remembering of what was learned. The hierarchy of partial activities, through which a student goes in the learning process and which are graded by level of difficulty, comprehension, demand factor, and requirements

of the studied subject matter, was created by D. Bloom (Tollingerová, 1966). The following six degrees of knowledge are mentioned most often: remember, understand, apply, analyze, synthesize and evaluate information (Kostolányová, Šarmanová, Takács, 2009a, 2009b; Kostolányová, 2012).
The basic idea of the theory of programmed learning (Tollingerová, 1966) has been adopted: dividing the subject matter into smaller units, evaluation of these small units and the reaction of the educational system to student's understanding of the subject matter. In programmed learning the system reacts only to student's correct or incorrect answers. According to students' answers, the author-teacher controls (programs) education by branching the process of education into different directions. Observation of the student (education process logging will be described below) and giving feedback is adopted from the idea of adaptive hypermedial systems (AHS) (Brusilovský 2003a, 2003b), which are based on the retroactive reaction to user's behavior and movement in the system. Out of several kinds of adaptation (Kostolányová, Šarmanová, Takács, 2011b), the model described by the submitted inaugural dissertation deals with adaptation of the content of education – particularly with adaptation of study material according to students' individual needs.

Nowadays, it is common to use electronic environment in education. The abovementioned basic ideas, transformed to a new form – adaptive education – will be realized exactly with regard to this form of educational environment – adaptive eLearning environment. Any computer-controlled education is communication between the computer and the student, which makes such communication individual. A student who studies using a computer can be perceived as an individual so the education itself can then be prepared according to his/her individual qualities. However, it is not possible to apply this approach in the "normal" classroom with classic full-time study program. In the end, the suggested adaptive system should ensure and enable completely individual and personalized education of any number of students according to their knowledge and personal qualities.

Besides functional adaptive LMS (learning management system), a study material that can be adapted is necessary for practical execution of this idea. This study material is the core of the Author Module.

3. Adaptive study material

Author Module is intended for the creation, storing and maintaining of adaptive study materials. When creating the adaptive teaching aid, we can use the general method of **dividing textbooks** into chapters and subchapters – or in case of eLearning into lectures.

We divide the lectures into thematically united elementary parts, education steps. These individual education steps in the education process represent the sequence of elementary steps of learning. They create certain order in the sense of progress: beginning of the lesson, instruction, exercises, examination, completion. To be able to use this principle in the field of adaptive education, we describe the education process according to R. Gagné. This principle presents events that should be part of any educational unit (course, lecture, class).
When formulating the goals of the instruction we follow the revised Bloom's Taxonomy of Educational Objectives. When creating learning exercises, simple or group, authors of study aids follow the recommendations and taxonomy of learning exercises by Tollingerová (1966).

When contemplating the adaptability options of study materials we also used the methodology of the creation of distant-study materials. This is where the idea of dividing the study material into partial, smaller units, comes from. We divided the curriculum of one subject into chapters and subchapters. In subchapters, the thematically united elementary parts are called **frames**. Frame is an elementary education unit that explains one partial topic. It is the frame that is the main object of our focus when structuring the adaptive textbook, with several variants of instruction. For example the frame can deal with a newly introduced term (motivation for its acceptance, definition, explanation, application, example, test questions and tasks for solving). Formally speaking, the frame usually corresponds with the lowest level of numbered or otherwise marked paragraphs, or one internet page including multimedia elements.

To be able to adapt to different personalities of students, the managing teaching programme (Virtual Teacher) must have the teaching curriculum available in many **different forms** – similar to an experienced teacher reacting to different levels of knowledge, different talent and approach to learning, reactions, habits and other characteristics of each student.

Table 1: The nine events of instruction

Event	Procedure, Activity
Gain Attention	Introduce a problem or a new situation. Tell a story. Demonstrate a situation. Present a problem that needs solving. Show something in a wrong way (education will then show the correct execution). Emphasise importance, meaning.
Inform Pupils about the Goals	Allows pupils to organise their minds and prepare for listening, observation or demonstration/doing. Describe the aims of the lecture, define what they will achieve, show them how they can use it and benefit in future.
Stimulate Recall of Prior Learning	Enables pupils to build on their previously gained knowledge and skills, build relations. Remind pupils of their existing knowledge relevant to this lecture. Create context for things, it facilitates learning and retention.
Present the Material	Divide information into small parts; avoid memory overload. Use teaching strategies and tasks. Specify difficulty levels.
Guide through Learning	Formulate orders on how to learn. Use varying channels and media, explain the know-how to pupils. Learning effectiveness increases, because pupils do not lose time finding the way.
Initiate and Elicit Performance	Practice by letting pupils do the tasks on their own using the newly gained behavior, abilities and knowledge.
Provide Feedback	Show pupils the correct answers and analyse their reactions. You can use test, quiz or a comment. Feedback must be specific, not simply “you did good”. Tell pupils why they did well, provide guidance through their answers.
Assess Performance	Test to know whether pupils learned new things.
Enhance Retention and Transfer to Other Contexts	Inform pupils about similar situations, provide options of further exercises, introduce situations for transfer, revise the lecture.

Of course all types of instruction must be created by a real teacher – author. This will be a multiple times more demanding work than creating a distant-study textbook and the author must be experienced and creative, able to empathise with different types of students. Teachers also have their own teaching styles. Someone presents complete, continuous lecture, describes and explains everything, applies it in exercises, and then lets students revise the knowledge and apply it. Another teacher trusts their students’ creative input and starts with introducing simple exercises on the given topic. They help students with the solving, guide them and continue with more and more demanding exercises until together they come to the general validity of the learned experience. The aim is for the students to accept the given theory more naturally and remember it better. However, in mass education there will be students who like this approach, and others who do not. For our intelligent, adaptive education, the virtual teacher must have all styles of instruction at hand to be able to choose the best one for a specific student.

Teaching aids must therefore be structured to the minute details, to allow adaptation to the student by selecting the right variants of instruction and the right sequence of its components.

4. Principle of creating adaptive study material

The most prominent characteristic of a learning style is the sensory perception type, second most prominent is the quality of understanding of the instruction. We chose these two basic criteria to create frames in different variants **– form** of instruction for the given type of student’s preferred sensory perception and **depth** for the level of detail of instruction.

Therefore every frame must have sensory **variants:** one with a high prominence of text (for the verbal type of student); with many pictures, graphs, charts and animations (for the visual type); with spoken word, audio

recordings, communication and discussions (for the auditive type) or creative exercises, constructions, etc. (for the kinaesthetic type).

The second criterion is the division of variants by the depth of instruction. Study materials will be created in the "universal depth". This will be used as the primary depth. Students unable to comprehend the instruction formulated in this depth will have available a variant of modified instruction (more detailed, from different point of view, etc.) and students motivated by the given topic will have access to interesting facts and specifics of the given topic.

Author of the study material will be creating individual frames in four sensory variants with three different depth variants – 12 variants of one frame in total.

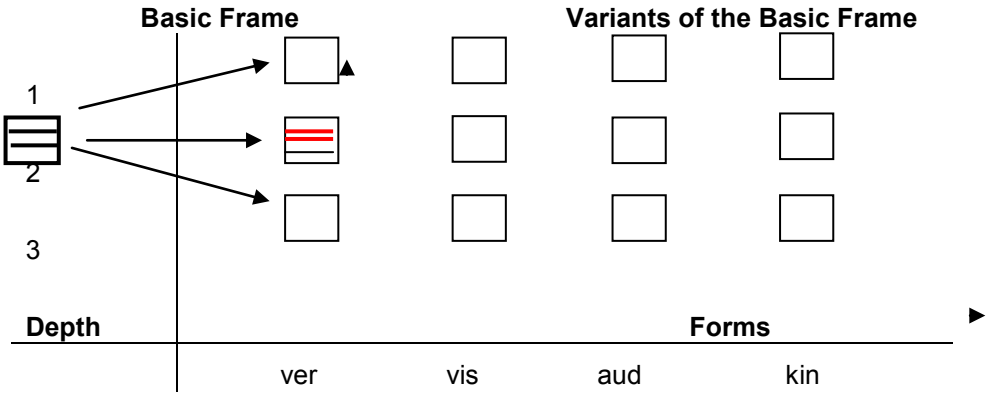

Figure 2: Frame variants

Variants that only differ in form and depth of instruction would not cover all required differences in the style of instruction. Instruction must react to other differences in personality characteristics of students. By analysing these student characteristics we concluded that instruction also differs in the sequence of partial components of the instruction and continuous testing, or organisation of information.

Adaptation of the instruction style of the frame is possible by dividing the frame into partial components – layers. **Layer** is such part of the frame that is homogenous from the point of view of the education process (theory (T), explanation (S), reinforcement (F), knowledge assessment ®, motivation (M), instruction management (N)) (Kostolányová, Šarmanová, Takács, 2011a).

We have designated these types of layers:

- *Instructional* – group of layers including the actual instruction of the subject matter (theoretical layer), instruction layer (semantic), revision (fixation layer), layer of theoretical school and real life exercises.
- *Testing* – group of layers for continuous testing of gained knowledge, consisting of questions, school exercises and practical (real-life) exercises.
- *Other* – such as goals, motivation layer, navigation layer, supporting material layer.

Information on the form and depth of instruction and type of layer must be recorded in metadata. With the use of metadata, the system can choose and manage the right way of teaching.

The instruction style of the frame can be changed by changing the sequence of individual layers, to be in accordance with a specific student's characteristics. With this type of adaptation, the frame does not lose its general instruction value. **Instruction management** is done by choosing the sensory variant and by changing the order and depth of layers. Using this approach, the teaching aid can be adapted freely.

5. Methodology for creating adaptive study aids

The creation of an adaptive textbook is much more demanding than the creation of a classic eLearning textbook. We tested this authorial work on several lectures of various types of subjects (technical, informational, language, natural science) and based on the experience of all authors we came up with a

methodology which will hopefully make the creation of adaptive study materials at least partially easier for future authors.
For the authorial work on adaptive textbook, it is wise to use an existing classic textbook, which is used in present lectures, for example. Afterward the following algorithm is advised:

1.For the selected subject create goals, define level of the subject, prepare the curriculum – contents, list of chapters.
2. Divide the chapters and subchapters into parts that correspond, in their scope, with the hourly classes (lectures), and name them.
3. Create goals and the content and level of each lecture; divide the lecture into elementary units (frames), and name them. Frames are the basic framework, starting point of further work. So far, this is a common procedure, suitable for the creation of any textbook.
4. Divide each basic frame into layers for classic instruction in the depth level of 2, "classic" execution, mostly in verbal form:

- define goals of the frame,
- define contents of the frame,
- divide frame instruction into layers, i.e. separate theory (definition of new terms and arguments, new rules, procedures, etc.), theory explanation, fixation layer (different formulation of the instruction, putting new information in context of previous knowledge, etc.),
- add layers with solved examples and real-life examples,
- add control questions to test new knowledge – or a group of questions,
- add tasks to be solved to test new abilities – or a group of tasks,
- contemplate and add motivation layer,
- contemplate and add navigational layer,
- add publications, if needed.

6. When the division of the basic frame into layers in depth 2 is ready, similarly create variants for depth 3 and depth 1.

To be able to focus on these tasks and not deal with how to write the teaching aid down, we created a form for the authors to facilitate their authorial work on a structured aid (Kostolányová, Šarmanová, Takács, 2011b). Authors put their teaching texts into it and fill out necessary metadata that are required for the formulation of adaptive algorithms (Kostolányová, Czeczotková, Šarmanová, 2010).

7. Use of adaptive study material in personalized education

To control adaptive eLearning education, besides psychological-pedagogical knowledge (e.g. theoretical solutions of adaptive education), based on which the detailed plan of the education process is compiled, we also need a structured study material and adaptive rules. These rules determine which type of study material will be assigned to which student. This way the optimal learning style for a particular student will be designed; and the optimal way of going through a study material will be suggested.

Adaptive rules will assign appropriately structured and created material, which stems from student's learning style, to a particular student. These rules must reflect student's preferred sensory perception (verbal, visual, auditive, kinaesthetic) and at the same time they must accord with student's characteristic qualities that define his/her learning style. Learning style is determined by the following qualities (their values can be used in the eLearning environment):

Today, the following "static" qualities that determine learning style are being tested, filed and used for education control:

- Affective aspect = motivation to study
- Social preferences (prefers to study alone – in pair – in group)

- Learning tactics (orderliness, how he/she processes information)
- Approach to study: deep – strategic – on the surface
- Autoregulation: the amount of ability to control his/her own study

During the course of study the "dynamic" quality that reflects "the amount of understanding" of the subject matter is being filed.
In the rules for the assignment of study material we follow student's defined learning characteristics to which we will assign suitable learning style. The rules can be formulated as follows:

- If the student has the Understanding quality = 3, for explanatory and testing layers use depth 2 first, then depth 3.
- If the student has the Understanding quality = 1, for explanatory and testing layers use depth 2 first, then depth 1.
- If the student has the Approach quality = 75 (Deep type), then use depth 2 first and then depth 1 in the order determined by the remaining rules.
- If the student has the Motivation quality = -50 (highly unmotivated), then use the motivation layer from depth 3 first (detailed motivation explaining practical contribution of this knowledge).
- If the student has the Motivation quality = 75 (highly motivated), then use the motivation layer of depth 1; if it is not available, leave it out completely.
- If the student has the Autoregulation quality = -50 (highly dependent), then use the navigation layer of depth 3 (introduction of detailed pedagogical study advice).
- If the student has the Theorist quality = 75 and Experimentalist = 25 (Theorist type), then use the following order of layers: theoretical – present theory with its interpretation, testing – test the theory, practical examples – add practical use and experience examples – test their use).
- Etc.

Formulation of these basic rules was proposed on the basis of experts' pedagogical experience. The rules are the basis for the creation and formulation of other rules which will stem from successive analyses, evaluation of education and continuous student-testing mechanisms. Those rules will include defined principles and conditions of a proper learning style which would make students with incorrect learning habits use more appropriate methods and ways of learning that are offered to them.

Based on specific characteristics of the students and using properly formulated rules for the adaptive algorithm we can assign specific study material to specific students in a given sequence, thus creating their individual style of instruction. Instruction management is firstly done through choosing a sensory form and then depth of instruction and sequence of individual layers. This way the potential of the multiple-variant study aids can be used to full by matching the preferred characteristics of individual students.

Personal sensory variant of the student is defined by their most distinct type of sensory perception. For other characteristics, general elementary rules are formulated:

if the student's characteristics V1=a and at the same time V2=b,
then use the sequence of layers and depth X, Y, Z, …)
where: X, Y, Z … individual layers (theoretical, semantic, …)
V1, V2 … characteristics of learning style (motivation, self-regulation, …)
a, b, … are the values of the given characteristics.

Rules assigning the sequence and depth of the selected layer are expert rules defined by an expert – pedagogue and expert on adaptive education. There are many "elementary" rules – for every value of every rule and their combinations (Kostolányová, Šarmanová, Takács, 2011b).

These rules cannot be fine-tuned in real education – at this moment there are not enough adaptive study materials (their creation is much more complicated than the creation of regular distance textbooks) and not all types of students will always be present in actual education. For this reason a separate module was created that is part of the adaptive LMS being developed and that will allow education modelling without actual

teaching aids/materials. Teaching is simulated for all types of students. Correct formulation of elementary rules is verified as well as the algorithm for obtaining the so-called personal learning style, i.e. the sequence of layers and depths of a study material.

8. Management and Modelling of Optimal Education Process

Information on the learning style of the student (values of each characteristics that determine the learning style) and information on the structure of the study material (metadata on individual parts of the study material) serves as the inputs of the management teaching programme called the Virtual Teacher (VT). The Virtual Teacher is a type of expert system that includes basic pedagogical rules and uses these elementary rules to create optimal teaching style for the given student and optimal progress the given teaching material. The process of education management is complicated yet invisible for the author, teacher and student. Modelling the process is crucial to verify the correctness of designed adaptation rules.

To fine-tune basic functions of the virtual teacher (model and a subsequent simulation of recommended teaching) we need to define all basic types of virtual teachers and all variants and layers of the teaching aid.

Virtual students are assigned learning characteristics. The learning characteristics of students are given certain values. By combining the values (each characteristic has 2–4 values) we obtain around 2000 possible types of students. We simulate the teaching for each individual student or groups of student with identical one or several values. The virtual teaching aid is modelled only by defining its metadata.

For testing purposes, the modelling tool itself uses the expert rules and the mentioned algorithms to determine the personal education style (PES = determining the optimal sequence of layers of the teaching aid) and actual education style (AES = determining the actual sequence of layers using those that are available; had been created by the author). The tool can visualise the progress of different types of students through the study material, which allows examining their learning styles. It also serves as the basis for the analyses of how many times a student went through the individual parts of the teaching aid. The special method of visualisation of the results of PES and AES displays the pattern of all theoretical variants of one frame (sensory type and depth of instruction) with all possible layers. Into this pattern, it draws the learning progress as proposed by the virtual teacher – seen as a connecting line of individual layers in the given sequence and depth (Fig. 3). We call this diagram a trace of the adaptive education process, in short: education trace. Each trace mirrors one learning style of one type of student. The tool can draw more education traces with one common parameter (the parameter consists of different individual characteristics of the learning style).

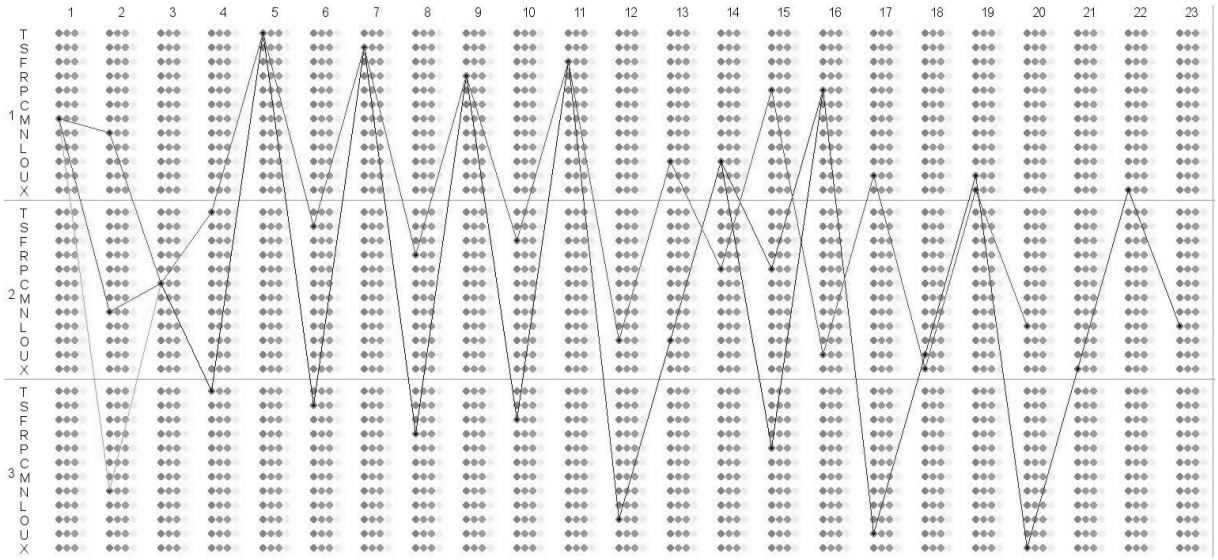

Figure 3: Trace of the Adaptive Education Process

(layers: theory (T), explanation (S), reinforcement (F), knowledge assessment ®, motivation (M), instruction management (N), goals (C), examples (X), literature (L), homework (U), question (O))

9. Implementing the Module for Simulated Adaptive Learning

Modelling the process of adaptive education will take place in two phases. The first phase will test the correctness of designed elementary and complex rules for assigning teaching material in an ideal teaching aid (one that contains all variants of all layers). This will identify any possible errors during the creation of PES. The second phase will model the AES, i.e. the study aid will not be complete – some variants of layers will be missing (Kostolányová, 2012).

The first phase of the education process modelling will test elementary rules at first; for this reason individual characteristics of students are incorporated gradually, not all at once. Characteristics selected for the testing included motivation, notion of learning, depth of learning, self-regulation and success rate. Values of individual characteristics are usually set to three whole values (0, 50, 100 or -100, 0, 100): minimum, average and maximum.

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

Process of modelling individual elementary rules:

- Simulation of education with "average" student in all characteristics (their PES should be the "classic" one that is usually used in text-books);
- Simulation of education with the change of the value of the tested characteristic to high and low and a check on the functionality and correctness of designed expert rules. This approach is used for one student at first, then a group of students with the given value of the monitored characteristic and other characteristics being average;
- If the diagram does not correspond with the expert's notion of the expected PES, we notte down the error (incorrectly formulated expert rule, or erroneous function of the PES algorithm) (Kostolányová, 2013).

The same modelling tool will serve to verify if the rules are designed correctly for the case when several rules must be combined, which corresponds with various characteristics of the student. Combinations of two, three and four characteristics in all possible variants were chosen for the modelling. Example of two characteristics – motivation and self-regulation: combinations of average motivation and self-regulation was used; combination of low motivation and high self-regulation; high motivation and low self-regulation, etc.

During the modelling of elementary expert rules and complex rules, no errors in the rules or the PES algorithm were found. Problems arose with the combination of two specific characteristics: depth of learning and success rate of student. This situation was not sufficiently and properly analysed; from the pedagogical perspective the formulation of rules by preferred concept of learning in connection with the student's success rate are inadequate. After pedagogical discussion and consideration, rules were reformulated and given priorities over each other.

The second phase of modelling tested the functionality and correctness of the AEStyl algorithm. In real education, the Virtual Teacher does not have ideal study material at its disposal (i.e. with all layers in all variants of the curriculum). This part of the modelling focused on the use of correct variants and layers of the study material, if the study aid is incomplete.

The AEStyl choosing algorithm had to analyse the existing variants and layers and in case some of them were absent provide solution: substitute the missing layer with its "closest" replacement, if that exists, or simply leave it out if it does not exist in any other version.

The pattern will the show missing parts with a small black dot; larger dot (the modelling tools uses colour distinction for 4 senses) represents the existing variants of corresponding variants (see Fig. 4).

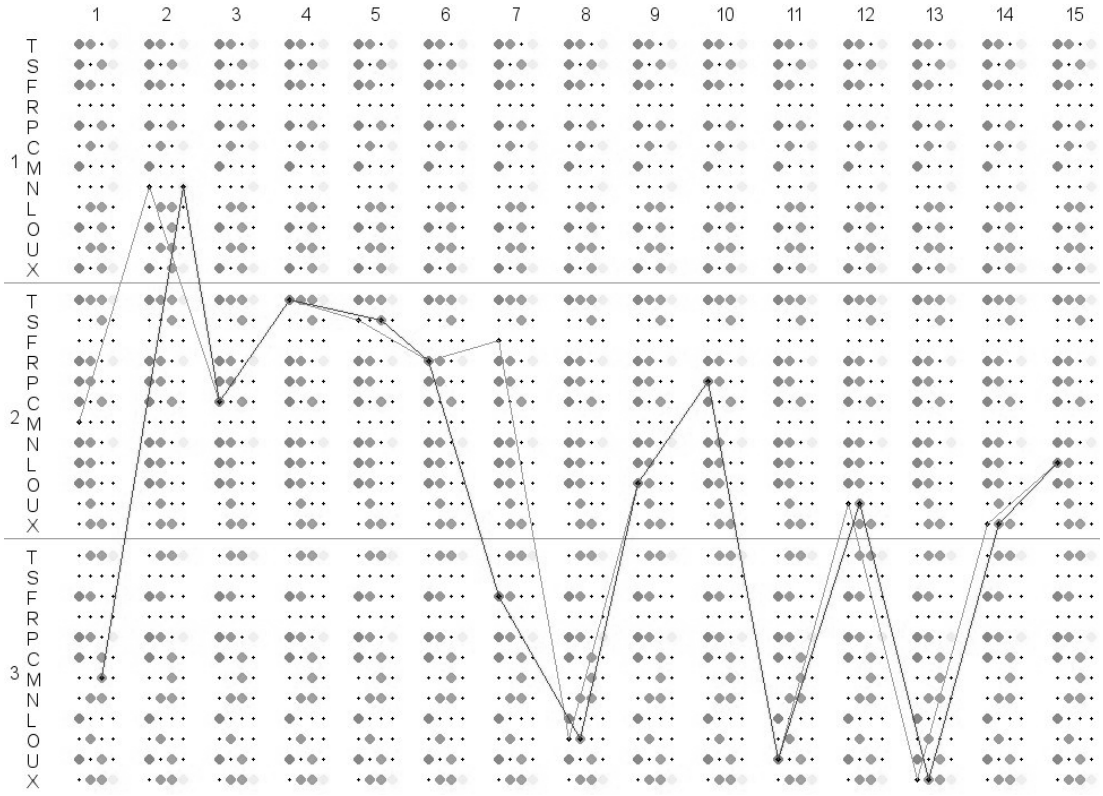

Figure 4: Progress of the Ed. Process with an Incomplete Aid

(layers: theory (T), explanation (S), reinforcement (F), knowledge assessment ®, motivation (M), instruction management (N), goals (C), examples (X), literature (L), homework (U), question (O))

Experiments verified a number of correctly executed substitutions or omissions of layers except for the following:

- missing layers were incorrectly duplicated instead of being omitted and replaced by their substitutes,
- in case the preferred sensory variant was missing it was replaced by other sensory variant instead of the second best preferred variant.

Discovered errors were corrected by a duplicate layer check that removes the duplicated layer from the AES. The AEStyl algorithm was modified to substitute the missing sensory variant with the second preferred sensory variant. In connection to this, the situation with identical values of sensory preferences of students was also solved: the substitution is being looked for from "left to right", that is in the sequence of verbal → visual → auditive → kinaesthetic. (Kostolányová, Takács, 2013)

10. Conclusion

Theoretical model of adaptive learning, the suggested methodology for creating study materials and groups of suggested rules are being tested by using modeling and simulation of individual cases – for different virtual students and different virtual study materials (with all possible variants of interpretation and testing).

Given the character of the process, Learning Management System (LMS) appears to be the best choice. Besides functions of the common LMS, the newly developed system must enable:

- testing of learning styles of students and recording them,
- saving of finely structured teaching aids into lectures, frames, variants and layers,
- manipulating these layers in order to be able to provide different students with different ways of instruction.

The development of such adaptive LMS has been under way as part of the research focus of the Department of Information and Communication Technologies (ICT) of the Pedagogical Faculty of University of Ostrava for four years. This system – Barborka – will have many other functions that are related to the complete education

process. It includes the function of Virtual Teacher, i.e. intelligent system that manages the teaching/learning process in accordance with the described principles. Record of the whole education process will serve as valuable feedback. It will enable the correction of characteristics of real life and virtual students and therefore the correction of the assigned teaching style. It will discover erroneous or unsuitably formulated instructional and testing parts of the study aids. Finally it will enable discovery of unsuitably defined principles of assigning a teaching style to a corresponding learning style. (Kostolányová, Šarmanová, 2013). The tool for modeling and simulation of the suggested optimal passing of individual students through the education process is now being implemented into the system. The modeling tool visualizes passing through the study environment on the basis of student's learning style and a study material, which is available (in adaptable structure and form) for the given subject matter. Evaluation of the individual simulations leads to uncovering of the possible incorrectly proposed rules, their preferences, and if need be to correcting of the mistakes in adaptive algorithms.

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