MODELING AND SIMULATION OF EDUCATION OF NATURAL SCIENCE SUBJECTS WITH E-LEARNING SUPPORT

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Abstract

To describe the management of communication between human being and the computer it is appropriate to employ graphic tools in order to describe and formulate the basic rules underlying this interaction. Interaction between student and LMS in the process of teaching and learning is a composite process and it is highly recommended to employ Petri nets for this purpose. The paper aims at presenting the principle of construction of linear and branching learning programmes and their subsequent formulation using Petri nets in education of natural science subjects.
Key words: *Petri nets, modeling process, operating systems, e-learning.*

Introduction

We live in an information society and changes, which are brought to the life of the society by information and communication technologies (ICT), are so important that they influence all spheres of our life. ICT facilitate our work and make it more effective. They enable information from the whole world, allow for fast and available communication among people. Development and infiltration of ICT into educational processes of the whole society influence the meaning and structure of education as well as competence of higher education institutions graduates. In connection with ICT in the area of education, we cannot solve solely the penetration of these technologies into the current teaching methods. The purpose must be a change of these methods in line with the requirements of the development of society and scientific and technical progress. These require finding associations and looking for new ways of using the knowledge of the given issues in various fields. The current development of teaching methods, which is described as a change of paradigms (Brdička, 2000), leads up from a simple handover and memorizing of information towards creative quest and finding of associations.

The change of elementary paradigms in the classical pedagogy affects the whole structure of education, all its components. It is manifested in all its levels (Malach, J., 2002): in the process of teaching there comes to a significant shift towards learning systems focused on the user, a shift from knowledge to competences, from teaching to student-centred education. In the process of teaching, where fulfilment of tasks and finding associations are required, constructivist attitude and project education are gaining

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ground. In the new role of a teacher – teacher becomes a guide and assistant of learners, a designer and manager of instruction. He designs and creates materials and situations for active learning of learners, consults, gives advice, helps, unites groups of students together and leads their activities. In the roles of learners - students in the process of instruction are divided according to their abilities and interests, cooperate with other students as well as teacher upon solving projects, which individually assess. A teacher guides students to discover errors and insufficient solutions, which then become a source of further advice and motivating factor of the learning process.

The main purpose of the above described change of paradigm is more open, more accessible and liberal education, focused more on the development of an individual and personality of a man. Its unsubstitutable role in this change is played by ICT, which should undoubtedly be integrated into the educational area. A whole range of methods and methodical procedures in education with an ICT support, such as computer-aided education, e-learning, education using mobile technologies (m-learning) has been written and elaborated in details. The suggested paradigms aim at presenting opportunities and ways of education and learning in new conditions of the knowledge society. This process must be aimed at a complex information education towards abilities to process information and change them into the widely utilizable knowledge (Brdička, 2000).

Opportunities to Use Petri Nets

When modelling the educational process it is necessary to draw from interaction understanding, from mutual social interactions of participants of the educational process. A „general model of educational process“, was thus created, which includes wider environs, input factors, the process itself and its products (immediate results and long-term effects) (Prokeš, 2008).

T. Vojta (2002) was attempting to make a simple technical model of the process of teaching without a further practical reference. The modelling means were Petri nets, by means of which he modelled processes of acquiring the concepts from the area of algorithms and programming.

The proposed structure of the subject „Principles of operating systems“ will be applied using modelling tools of Petri nets (see below). Regarding the continuous development in the area of ICT there must be created an e-learning course for the above mentioned subject, to remain open to new technologies, opportunities and procedures, applicable in projects solving. The proposed Petri network must thus be formulated in modules so that it could be possible to complete or suitably adjust it in case of need.

One of the assets of modelling the teaching processes by means of Petri nets is their formal description, which is complemented by a visual graphic representation. A precise and accurate specification of the process is thus allowed, which enables us to remove ambiguities, uncertainties and dubiousness and contradictions. Besides the visual graphic representation, Petri nets have also solidly defined mathematic foundations, which can be appropriately used in various software tools for the specification and analysis of computer solved corporate processes. For the description of teaching processes, such as browsing in the study material in e-lerning education, it is appropriate to use mathematic and graphic methods, where mainly serial machines are successfully used, which, however, have certain limitations. These issues could be solved more effectively using Petri nets for their precise and exact specification. In extensive teaching materials, where bonds among individual activities could be described only partially, it is suitable to build in fuzzy logics in the classic Petri nets.

Petri Nets

Petri nets are one of the most widely used tools for modelling and designing complex systems with parallel processes and hierarchic structure. They have innumerable applications in the area of data processing, parallel programming, operating systems, distributed databases and management of complex processes of any kind including designing and modelling information systems.

Petri nets can simply model the synchronization of processes, parallel operations, conflicts or source allotment.

Definition of Petri nets

A Petri network is a biparty oriented graph, represented by a tetrad $PN = (P, T, PI, TI)$, where:

$P = \{p_1, \ldots, p_n\}$ is a definite set of places

$T = \{t_1, \ldots, t_m\}$ is a definite set of transmissions $P \cap T = \emptyset$;

$PI\ (p, t)$ is a depiction of $P \times T \rightarrow \{0, 1\}$, corresponding to the set of oriented edges from the place to the transmission

$TI\ (t, p)$ is a depiction of $T \times P \rightarrow \{0, 1\}$, corresponding to the set of oriented edges from the transmission to the place

$$\forall t \in \mathrm{T}: TI(t) = (PRECOND_t, POSTCOND_t)$$

where $PRECOND_t : P \rightarrow N_0$ are input conditions of transmission t;

$POSTCOND_t : P \rightarrow N_0$ are output conditions of transmission t.

The set of edges of the Petri network is the set $A \subseteq (PxT) \cup (TxP)$, where

$$\forall (p,t) \in (PxT)[(p,t) \in A \Leftrightarrow PRECOND_t(p) > 0]$$

$$\forall (t,p) \in (TxP)[(t,p) \in A \Leftrightarrow POSTCONFD_t(p) > 0]$$

If $(p,t) \in A \cap (PxT)$, we can say that p is an input place and (p,t) input edge of the transmission t.

If $(t,p) \in A \cap (TxP)$, we can say that p is an output place and (t,p) output edge of the transmission t.

The values of the function TI (values $PRECOND$ and $POSTCOND$) are designated also as scales or multiplicity of individual edges of the network.

Marking of the Petri network PN represents $M: P \rightarrow N_0$, which allots nonnegative intergal number to each place of the network, showing the number of tokens (marks) situated in it.

The transmission t is *realizable* at the given marking M in case, and only in the case, when at least one token is situated in each input place p of the transmission t , i.e.

$$\forall p \in P[PRECOND_t(p) \leq M(p)]$$

When the transmission is realizable, it can be performed: token is removed from all input places of the transmission t (an element of the preset t) and generated in each place of transmission t (in elements of the postest t). New marking M', alloted after a single realization of the transmission t, is defined as follows:

$$\forall p \in P:[M'(p) = M(p) - PRECOND_t(p) + POSTCOND_t(p)]$$

Networks considered in this article, where PI and TI take the value of the set {0, 1}, are called „ordinary Petri nets“. An example of the Petri network is described in the following Figure 1; we mark it PN_1. The places are represented by rings and transmissions by rectangulars. This is a convention, which is in case of ordinary Petri nets generally accepted.

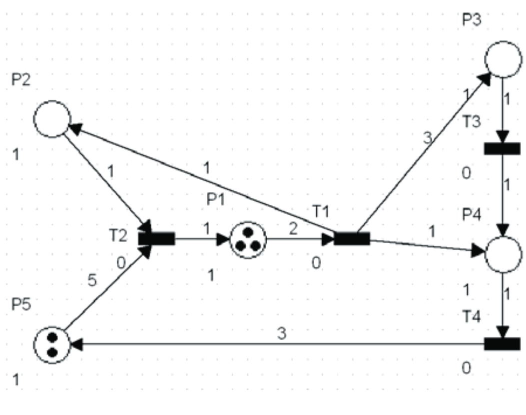

Figure 1. Model in the Petri nets.

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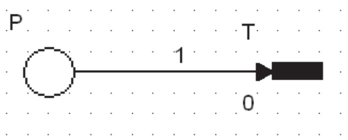
Structure of this Petri network, i.e. tetrad, which defines it, can be represented as follows:

$P = \{p_1, p_2, p_3, p_4, p_5\}$

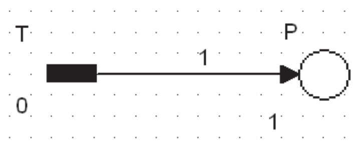
$T = \{t_1, t_2, t_3, t_4\}$



⇔ ***PRECOND* (*p,t*) ≠ 0**

Table 1. Model *PRECOND.*

P	*T*	*PRECOND (p,t)*
p_1	t_1	2
p_2	t_2	1
p_5	t_2	5
p_3	t_3	1
p_4	t_4	1
	Else	0



⇔ ***POSTCOND* (*t,p*) ≠ 0**

Table 2. Model *POSTCOND.*

P	*T*	*POSTCOND (t,p)*
p_1	t_2	1
p_2	t_1	1
p_3	t_1	3
p_4	t_3	1
p_5	t_4	3
	Else	0

The set of all input places of transmissions *t* refer to •*t* and we call it a *preset t*, the set of all output places of transmission *t* refers to *t*• and we call it a *postset t*. Identical notation will be used also in places: *preset* •*p* will refer to the set of all input transmissions of places *p*, while *postset p*• denotes the set of all output transmissions of places *p*.

By defining the set of places, set of transmissions and preset and postset of either all places or all transmissions, we get an equivalent representation of the structure of Petri network. Concepts of preset and postset are very useful upon describing algorithm for the analysis of Petri nets (Klimeš, Balogh, 2005).

Methodology of the Research of Teaching Programm Modelling

In terms of the degree of obligation of individual steps sequences for a student, we differentiate two main types of teaching programmes: linear and branch ones.

Linear teaching programmes prescribe for all students a fixed and binding sequence of steps in one line. The contents of education is explained in small amounts of information, however, the best way is to pass only a single information in each step. The created concept is practised as to the need and until the student handles it. By adding one concept to another one the student gets acquainted with the whole material and its issues. Briefness of steps does not allow for developing a prosaic style of explanation, so linear programmes are monotonous and after a certain time they become unexciting and tiring for many students. From the beginning till the end there is a single straight line consisting of rules, examples and answers. Opponents of linear programmes state that very small steps interrupt in an unwanted way the train of thoughts of a student. According to practical experience linear programming is suitable for teaching elements and principles of a problem and for the creation of the vocabulary and new concepts (Figure 2).

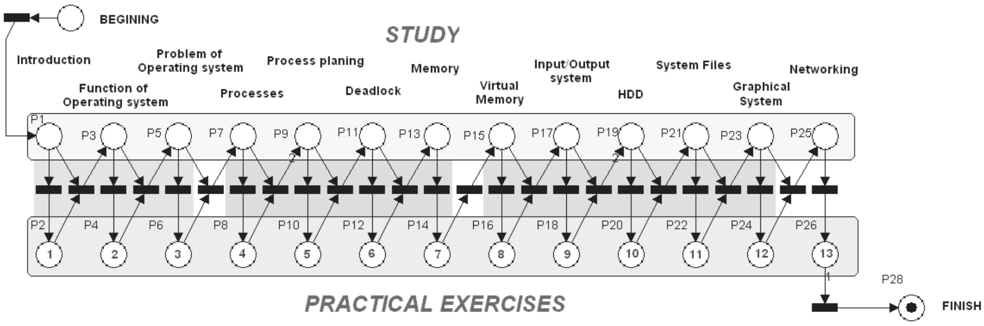


Figure 2. **Linear model of study with Petri nets.**

Branch programmes allow manifold procedures when solving problems. Alternatives of „branches“ of the programme lead to the successful common handling of the problem, however, each student passes the way, while its length corresponds to his personality, knowledge and talent. When teaching facts, the programme includes a clear main line, from which evert and than connect various forms of side lines (Figure 3).

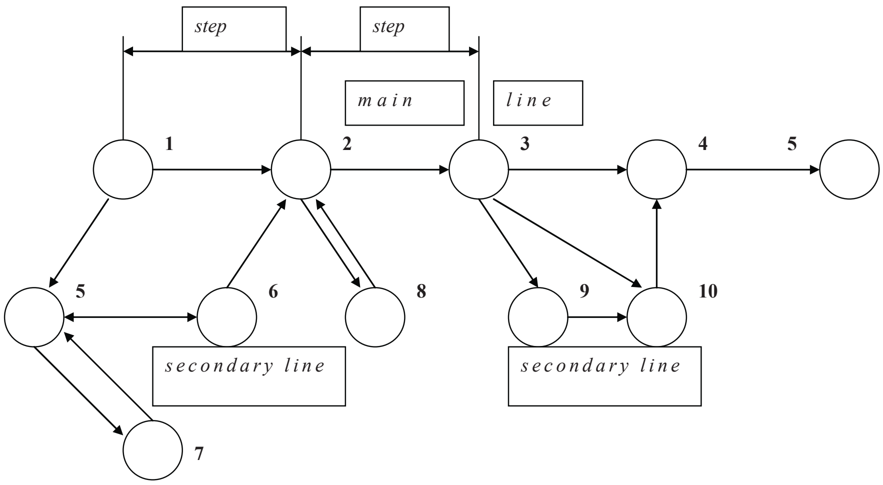


Figure 3. **Scheme of a branch programme with a single main line.**

The main line usually allows for a procedure in larger and more demanding steps, which can be managed only by an endowed (talented) student, responding appropriately to the inserted checking questions. Shorter and lighter steps for less endowed students and those working more slowly run in side branches. Then are inserted exercises for a successful practising of the given material, task, instructions and guides, referring students to for ecxample the solution of the attempt, or using of a visual aid or sequence, complementing the contents of education so that the opinion or fact was strengthened.

Larger contents of information of individual steps in a branch programme allows its activation in the form of a dialogue, which is more attractive also for the student. Branch programmes are useful especially there, where provision of new information and manipulating with them are in question. Their basic benefit is that they allow the student to choose an individual way of proceeding along the line, which corresponds to his intelect and previous knowledge.

Each of these basic types of programmes has also further variants. A student either creates answers to the questions, or chooses one of the provided variants of answers.

Research Results in the Area of Operating Systems

The aim of the research in the area of Operating systems was to create a new methodology of teaching the subject „Operating systems“ with the use of structures of Petri nets. The main contribution of the research is the creation of complex teaching texts and e-learning courses for the instruction of operating systems and the related subjects in university education, verification of their effectiveness, and last but not the least, their publication in the form of books or/and electronic publications. The consequence of the whole research, its purpose and at the same time expected (higly positive) contribution is shortening of the procedure and increasing the visualisation of instruction of operating systems, which results in increasing the level of knowledge of students and improving the quality of seminary works and diploma works of students at universities in the sphere of Operating systems.

Methodology of creation of an instruction model with a support of an e-learning course

For the sake of modelling we had to choose a suitable software means, which would reflect our needs. The programme HPSim, which is a freeware suitable for research and educational purposes, was selected. Its advantage is a simple installation, light control and excellent possibility to simulate parallel processes. HPSim allows for modelling by means of P/T Petri nets with inhibitors and testing edges (Markl, 2003).

When designing the structure of the electronic course, the following principles of self-study were taken into consideration:

- Clear definition of objectives of the course, as well as individual chapters,
- Simple and understandable style of writing,
- Transparent structure of the text in individual logical units,
- Clear visualisation,
- Support of self-study in the form of a direct instruction, discussion groups, etc.

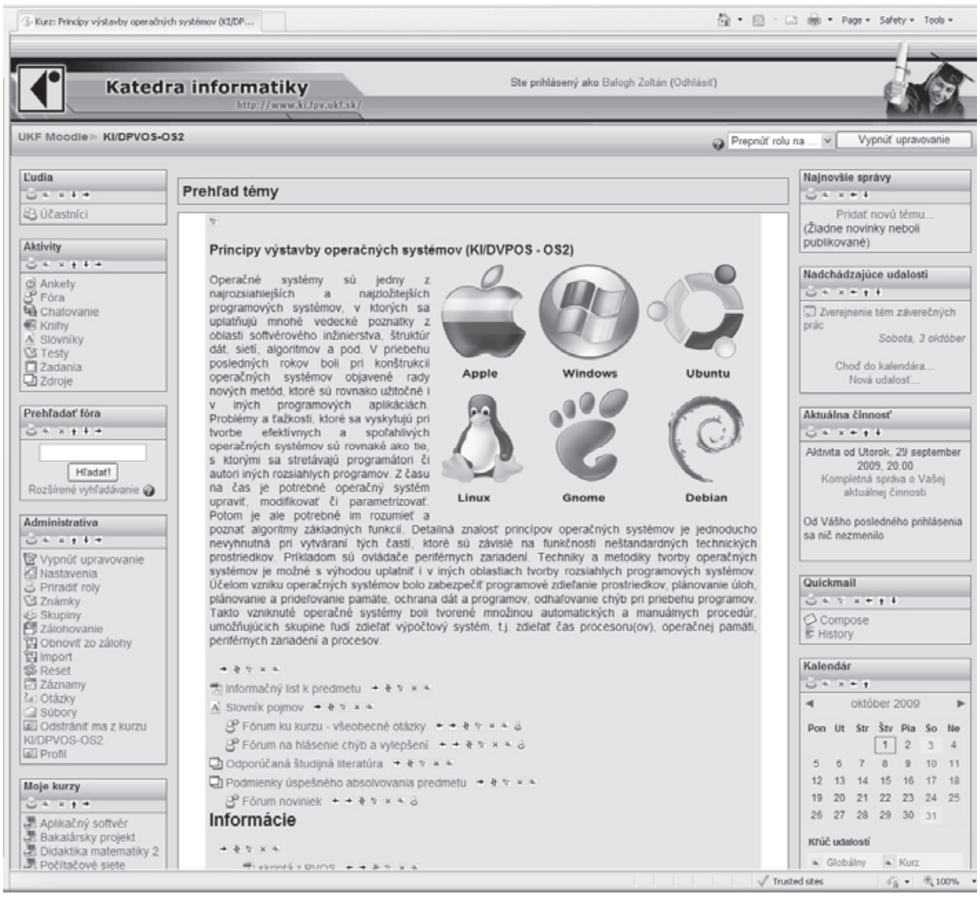


Figure 4. **E-learning course of Operating system.**

When creating the course itself, all aspects of e-learning creation were taken into account. A correct e-learning course should contain the following basic elements of the creation of the explanatory part of e-materials:

- introduction,
- objectives of study,
- time schedule and guidelines to the study material,
- explanatory text complemented by solved exercises, continuous questions, tests, etc.,
- correspondence tasks,
- summary,
- final tests,
- vocabulary of terms,
- literature, important references, annexes, etc.

Individual chapters in the course are enriched by the conjoint figures and animations, which help to easily orientate oneself in the course.

Except for the basic parts of the designed and created e-course it is very important not to forget about the part, which informs pedagogues on effectiveness of the knowledge being offerd in individual lectures of the e-course. This information is possible to obtain from the students in the form of a feedback, discussion forums, or by means of final tests, which are also a part of the created e-course. An important indicator are also log files on the activity of each student, who passed the offered e-course.

Conclusion

At present, didactic effectiveness of the e-learning course „Operating systems" is verified based on the model created by means of Petri nets. In order not to diminish the power of statistic results of created tests, we shall verify their validity and we shall use reliable and valid measuring procedures for data mining (pretest, posttest) (Munková, Munk, 2007). For the solution of this research problem two methods will be used: analysis of variance and analysis of covariance, where the analysis of variance is more simple and does not require the assumption of the homogeneity of regression in individual groups. On the other hand, interpretation is less valid, when between groups exist differences in the controlled variable (pretest) (Munk, 2007). Similarly to other situations it is recommended to execute both ways of analysing and comparing their results. On condition that the results will be identical we can consider them robust.

In order to apply new forms and methods of teaching the subject from the area of operating systems of computers, we had to analyse the current state and contents of education process from this subject. After the survey a certain model was designed, which could cause shortening of the progression and increasing of the visualisation of instruction of operating systems, which results in the increase in the knowledge level of students and improves the level of their seminary and final works. The created e-course dealing with operating systems of computers is used as a complementary study material and an aid for the instruction of the subject „Principles of construction of operating systems" for students with the focus on informatics. The current results point out to the suitability of application of Petri nets to the creation of instruction supporting e-materials for the students of informatics study programmes realized at the Department of Informatics of the Faculty of Natural Sciences of the CPU in Nitra.

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