УДК 37.02

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THE USE OF ICT IN IMPROVING THE EFFECTIVENESS OF THE DIDACTICAL PROCESS

The article deals with the issue of monitoring the didactical process using the Quela didactical process management system. It uses the developed educational environment describing the didactical process by using differential equations. The equations are represented in the form of a network of connected elements describing the individual components of the didactical process. Process monitoring has been carried out by simulations of the above network. The description includes learning and forgetting phenomena. Examples of the application of developed techniques in real pedagogical situations are presented.

Keywords: *learning tools, didactical process monitoring, smart learning environment, didactical analogy, simulation of didactical process*.

1. Introduction.

Currently, Smart Learning Systems (Essa, 2016) are under development. SLS are dedicated to conducting the learning process using e-learning platforms. The systems enable individualization of the learning process by adapting the content to the student's needs. They integrate a number of modules including modules for planning and accounting for learning activities. However, there are no systems that allow the design of the didactical process in terms of the effectiveness of the entire process. These issues were studied in the field of production management related to frequently repeated activities on production lines (Jaber, Saadany, 2011). The forgetting curves were used to determine production efficiency and to minimize the costs of the entire process. The functions of the power form, exponential form or superposition of exponential functions were used. In didactics, the issues of forgetting curves were used to build the SuperMemo program (SuperMemo, 2017). The program allows to increase the efficiency of learning by applying a repetitive algorithm. It is very effective, for example, for learning words of foreign languages. The SuperMemo algorithms used exponential functions to describe the forgetting process (Woz´niak, Gorzelan´czyk, 2005). The SM-1..11 algorithms have been implemented in subsequent versions of the SuperMemo (Woz´niak, Gorzelan´czyk, 1994).

The aim of the article is to discuss the monitoring of the didactical process in terms of effectiveness.

1.1 Didactical process monitoring.

In the work the author used a different approach to the issues of designing the didactical process. Differential equations and developed educational environment were used. On the basis of the network equations, models of elements describing particular elements of the didactical process were created. The didactical process is presented in the form of element network schematics or in a block form. This network can be easily simulated and analyzed using Dero microsystems simulator (Plaskura, 2013). For the representation of network equations, the analogy to electrical networks was used, which are widely known and for most people intuitive. Solutions of network equations describe dynamic learning and forgetting processes. The use of the category of learning objectives (Bloom's taxonomy) (Bloom, 1956) enables a more detailed description of the achievements by profiling students. The techniques described above have been implemented on the Quela platform. The methodology of designing the didactical process was introduced, which corresponds to the actual processes.

2. Implementation of the didactical process on the Quela platform

The Quela platform imposes on users a specific way to implement the didactical process at the planning and implementation stage, thus modeling the didactical process. The system consists of modules modeling real processes: the ECTS catalog, the catalog of learning objectives using the categories of learning objectives defined in Bloom's taxonomy (Bloom, 2017), the system of assigning and accounting didactical staff, the class scheduling system, simulation and optimization module of the learning process, gradebook and examination module. The use of the Quela platform enables process modeling on all four levels of the DIKW model (Baškarada, Koronios, 2013) (Figure 1). The data level is represented by the database of didactical materials gathered on the platform. The data are described by a set of parameters. The presentation of data is related to the flow of information (information level). The effect of the learning process is knowledge (3rd level).

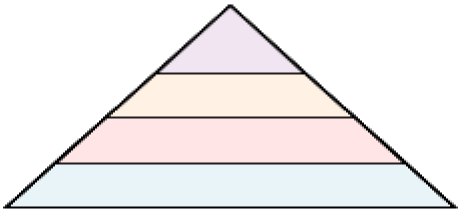

Figure 1: DIKW piramid.

Repeating the acquired knowledge allows for permanent memorization. Along with the acquisition of experience, the user is able to process and apply the acquired knowledge in practice, which leads to the wisdom (4th level). The 4th level can be modeled by user profiling taking into account the achievements for each category of learning objectives according to Bloom's taxonomy (Bloom, 1956) (Table 1). The simulation system can be used at the design, planning and implementation stage of the didactical process. Each student has the opportunity to simulate his own didactical process and anticipate achievements at the end of a given process. In this way, the didactical process can be adjusted in terms of the achievements set by the student.

Table 1: Categories of learning objectives.

(K)	knowledge
(C)	comprehension
(P)	application
(A)	analysis
(S)	synthesis
(E)	evaluation

The system makes it possible to determine the optimal repetitions for the set efficiency level at the selected time point of the didactical process. Initial data for the simulation system is determined by knowledge tests before the course starts. Based on simulation results, the didactical process can be modified to increase its effectiveness, understood as minimizing work inputs and maximizing achieved results.

3. Designing of the didactical process

The design of the didactical process starts with establishing learning objectives that should be entered into the educational objectives catalog. Taking into account the educational objectives, it is necessary to choose didactical materials. Didactical materials are related to the knowledge that every student must acquire at the education stage. These materials should be grouped in terms of the domain of knowledge and the order of learning. On the basis of groups of didactical materials, courses should be created that will implement relevant issues or groups of issues. For each subject, the scope of the material and detailed issues to be carried out during the didactical process must be determined. These data should be included in the description of the course in the ECTS catalog along with the relevant list of literature. Each course should be given the right ID according to the standards developed in the organization. The next step is to determine the hourly scope of the tasks. The hourly scope results from the time needed to implement relevant groups of issues described by didactical materials planned for use during the process. The next step is assigning classes to the appropriate lecturers. Each lecturer has the opportunity to make changes to the planned course and update it according to the latest knowledge. The ECTS catalog contains descriptions of objects and hourly dimensions of individual tasks. In the next stage, a detailed description of the didactical process is created, dividing it into didactical units. The didactical material is assigned an appropriate mathematical model describing the implementation of a given part of the didactical unit. Based on the designed didactical units, simulations of the didactical process can be carried out using a microsystems simulator. The simulation allows to determine the duration and distribution in time of individual units in terms of the assumed learning objectives. On this basis, you can optimally plan didactical activities. In the case of prior planning, the plan can be adjusted accordingly.

Each student has the opportunity to simulate his own didactical process and anticipate achievements at the end of a given process. In this way, the didactical process can be adjusted in terms of the achievements set by the student. The system makes it possible to determine the optimal repetition for the set efficiency level at the end of the process.

3.1 Model of learning and forgetting

The didactical process is described by differential equations modeling information flows and dynamic phenomena occurring during learning and forgetting. The solution to the differential equations is similar to the superposition of exponential functions known from the literature (Murre, Meeter, Chessa, 2007). The following time constants of learning and forgetting were used. The learning time constant τ_L =20*min*. The forgetting time constant τ_F models forgetting for short and long-term memory. It depends on the time elapsed since the last learning and from the repetition number of material *p* (1).

$$\tau_F = \begin{cases} p_m \cdot 1h, & t_{Ln} \leq t \leq t_{Ln} + t_c \\ \sqrt{p_m} \cdot 31d, & t > t_{Ln} + t_c \end{cases} \qquad (1)$$

where: $t_C = t_S/p_m$. For $p = 1$, the time of full change of the time constant t_S of forgetting was taken for 9*h*. Repetition of the didactical material is modeled by introducing a multiplier of time constant dependent on the repetition number (2).

$$p_m = \prod_{i=1}^{P} \frac{i+1}{i} \qquad (2)$$

The time constant τ_L as well as t_S is reduced. The time constant τ_F is extended. The presented model is a simplified model for a single category of educational objective. The full model is a duplication of the above-mentioned model for the other categories of learning objectives listed in the Table 1. The issue of creating a model of the didactical process using differential equations and a microsystems simulator goes beyond the subject of this article. Detailed information can be found in the technical documentation of the Quela platform (Quela web page, 2017) and in other publications.

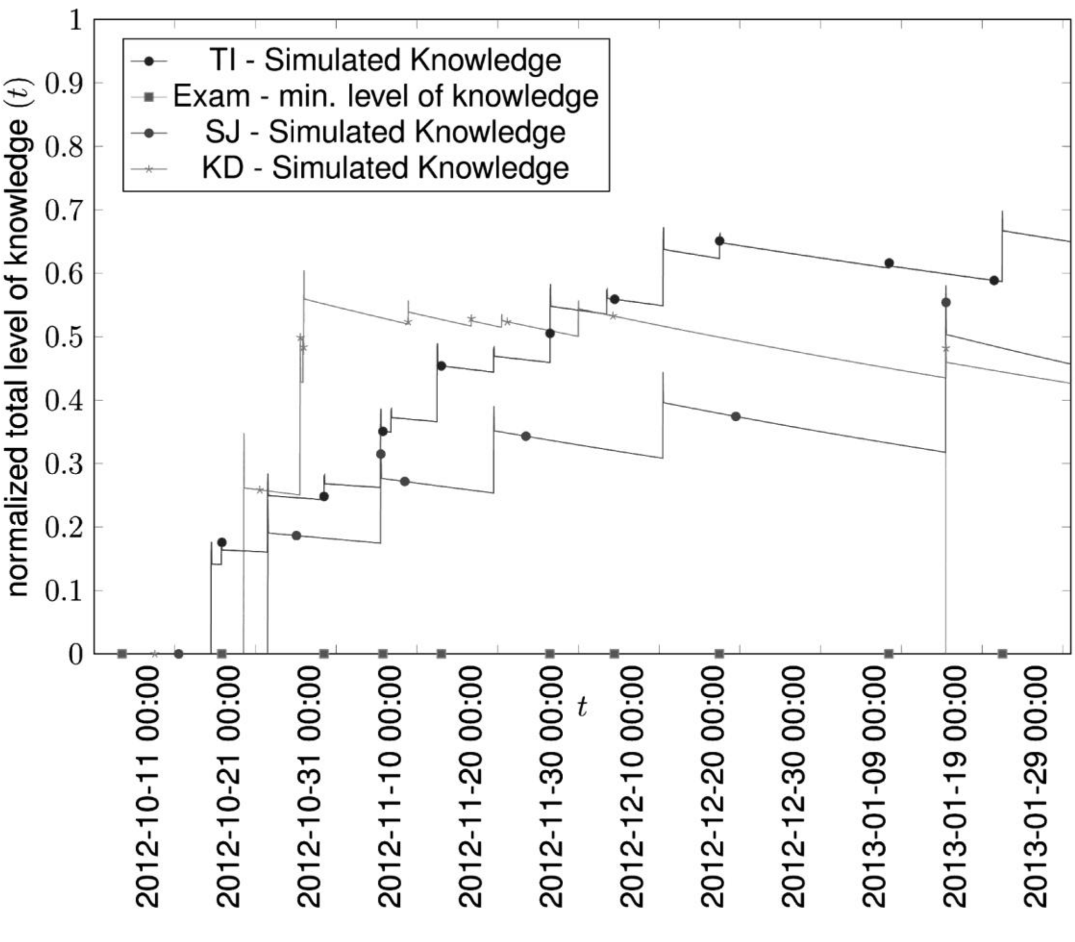

Figure 3: The simulation results of the TI course.

4. Results and Discussion

The system has been used to design and simulate the didactical process. The Figure 3 presents the simulation results of the designed course (*TI*) and the simulation results of the course carried out by the students. The didactical process was simulated over time during the course (several months). The process includes many didactical materials. The default parameters of the element models describing the learning process have been adopted. The minimal level of knowledge is set at the level of 0.51 (51%) (the variable *Exam*).

This is the grade 3 on the grades scale (2−5). The designed level of knowledge (*TI*) at the time of the exam exceeds the minimum level.

The actual results of simulation of the user's courses for one category of learning objectives are also presented in the Figure 3. Description of the process was generated based on the user's activity. Repetitions of the material have been included. The level of simulated knowledge is described by the SJ variable. The chart shows the absence of the student for every second class and lack of activity a month before the exam. It is not possible to pass the presented course without learning. The simulated increase in the level of knowledge before completion is associated with a short repetition of the material that took place before evaluation. The difference between the obtained grade (5) (not shown in the Figure 3) and the simulation results differs by 2 grades (scale 2 − 5). It can mean that the student has used other materials outside the system or copied didactical materials. The need for additional testing of knowledge should be considered.

The didactical process for the student KD represents the variable *KD*. The lack of activity can seen a month before the exam. The result of the exam (not shown in the Figure 3) coincides with the simulation results (grade 3). The course of the whole process may indicate the use of other didactical materials outside the system.

5. Conclusions

The discussed system has been used in practice for the design and simulation of educational processes. The results confirm the correctness of the project and its usefulness in the design and monitoring of educational processes. Simulation of the didactical process makes it possible to draw conclusions about the correctness of a given process and user behavior. It can be used to plan, correct and follow the didactical process in terms of its effectiveness. The further work will focus on: models verifications and modifications, the use of the faster simulation techniques, further development.

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Павел Пласкура

ВИКОРИСТАННЯ ІКТ ДЛЯ ПОКРАЩЕННЯ ЕФЕКТИВНОСТІ ДИДАКТИЧНОГО ПРОЦЕСУ

У статті розглядається питання моніторингу ефективності дидактичного процесу з використанням авторської системи дистанційного електронного управління Quela. Для моделювання дидактичного процесу використовуються диференціальні рівняння, що описують мережі з'єднаних елементів, які характеризують окремі компоненти дидактичного процесу. Моніторинг ефективності навчання здійснювався за допомогою моделювання вищезгаданих мереж, що симулюють процеси запам'ятовування і забування студентами модулів навчального матеріалу. Наведено приклади застосування розроблених технологій у реальних педагогічних ситуаціях.

***Ключові слова**: інструменти навчання, дидактичний процес, моніторинг, інтелектуальне навчальне середовище, дидактична аналогія, симуляція дидактичного процессу.*

Одержано 09.02.2018 р.