Computer Simulation of the Competencies and Motivation Levels in the Context of Student – Tutor Interaction

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Abstract

The purpose of the present work is to describe the process of teaching students, considering such parameters as the level of competence, the level of motivation, the level of acceptance of the material. The method of random numbers was used for the evolution of parameters in time, as well as the hypothesis of the dependence of the growth of competencies on other parameters. Several of such parameters have been tested. An algorithm and the software for it were developed, numerical experiments about the influence of parameters of studying on changes in students' competence over time were obtained. The plausibility of the different models of the teacher's influence on these parameters was estimated.

Keywords

Education process, modeling, competency, motivation, numerical experiment

1. Introduction

The question of motivation of the education can be called central as the motive is a source of activity and performs function of motivation and a meaning making. It considered that results of human activity for 20-30% depend on intelligence, and for 70-80% - on motives.

The motivation is an incentive of oneself and others to activity for achievement of the personal purposes. Either activity without motive or with weak motive is not carried out in general, or it is extremely unstable. Therefore, it is important that all process of training caused in the child intensive and internal motivation to knowledge, intense mental labor.

Development will be more intensive and productive if it is included in the activity corresponding to a zone of its next development if the education causes positive emotions, and pedagogical interaction of participants of educational process will be confidential and strengthening a role of emotions. In order to achieve good academic success, it is necessary to make learning a desirable process.

Types of motivation:

1. The motivation lying out of educational activity

• "Negative" are motives of the school student, caused by consciousness of inconveniences and troubles which can arise if he does not study.

• Positive in two forms:

is defined by social aspirations (feeling of a civic duty before the country, before relatives)

is defined by personal motives: approval of people around, way to personal wellbeing, etc.

2. The motivation lying in the most educational activity

- • Connected directly with the doctrine purposes (satisfaction of inquisitiveness, acquisition of a certain knowledge, expansion of an outlook)
- • It is put in the process of educational activity, (overcoming obstacles, intellectual activity implementation of the abilities)

The motivational basis of educational activity of the pupil consists of the following elements:

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- focusing on an educational situation
- awareness of sense of the forthcoming activity
- conscious choice of motive
- goal-setting
- aspiration to the purpose (implementation of educational actions)
- aspiration to achievement of success (awareness of confidence in correctness of the actions)
- self-assessment of process and results of activity (emotional relation to activity).

Knowing motivation type, the teacher can create conditions for a reinforcement of the corresponding positive motivation. Training will be successful if it is internally accepted the student. If it leans on it requirements, motives, interests, i.e. it makes for it personal sense.

It is necessary to understand the general structure of motivation to the learning at this age:

a) Informative motivation:

Great interest in studying of any subject in initial classes meets seldom, but well in time children are attracted by different, including most difficult subjects.

If the student in the course of training begins to rejoice to the fact that he learned something, understood, learned something, - means, it develops the motivation corresponding to structure of educational activity. Unfortunately, even among well in time pupils there are not enough children having educational and informative motives.

The person enriched with knowledge only when this knowledge something means to him. One of tasks of school - to teach objects in such interesting and live form that the child most wanted to study them and to remember. Studying only according to books and by means of conversations is quite limited. The subject is comprehended much more deeply and quicker if it is studied in a real situation.

b) Motivation of achievement of success.

At high progress students with high progress the motivation of achievement of success is brightly expressed - desire well, correctly to perform a task, to receive the necessary result. In initial classes this motivation quite often becomes dominating. Motivation of achievement of success, along with cognitive interests, - the most valuable motive, it is necessary to distinguish it from prestigious motivation

c) Prestigious motivation.

The prestigious motivation is characteristic of children with high self-esteem and leader inclinations. It induces the pupil to study better than schoolmates, to be selected among them, to be the first.

If to prestigious motivation there correspond rather developed abilities, it becomes the powerful engine of development of the excellent student which will achieve the best educational results on a limit of the working capacity and diligence. The individualism, continuous rivalry with capable peers and negligence to the others distort moral orientation of the identity of such children.

If the prestigious motivation is combined with average abilities, the deep diffidence that is usually not realized by the student, to a dress with the overestimated level of claims lead to impassioned reactions in failure situations.

d) Motivation of avoiding of failure.

The motivation of achievement of success and motive of receiving an appreciation are characteristic to start training at school. Also at this time the second trend - motivation of avoiding of failure clearly is shown. Students try to avoid "two" and those effects that are involved by a low mark, - discontent of the teacher, sanctions of parents.

To the termination of elementary school the lagging behind school students most often lose motive of achievement of success and motive of receiving a high mark (though continue to expect a praise), and the motive of avoiding of failure gains significant force. Uneasiness, fear of receiving a bad note gives to educational activity negative emotional coloring. Nearly a quarter of poor third-graders is negative to the learning because at them this motive prevails.

e) Compensatory motivation.

By this time weak student have also a special compensatory motivation. These are the motives, collateral in relation to educational activity, allowing to be approved in other area - in sports activities, music, drawing, in cares of younger family members, etc. When the need for self-affirmation is satisfied in some sphere of action, the low progress does not become a source of heavy experiences of the child.

Usually the child comes to school positively motivated. That at it the positive relation to school did not die away, efforts of the teacher have to be directed to forming of steady motivation of achievement of success, on the one hand, and development of educational interests - with another.

Forming of steady motivation of achievement of success it is necessary to blur "a position poor", to raise a self-assessment and psychological stability of the school student. A high self-assessment underachievers of separate qualities and abilities, the lack at them of an inferiority complex and diffidence play a positive role, helping such school students to be approved with types of activity, feasible for them, are base for development of educational motivation.

The motivation has the greatest influence on productivity of educational process and defines success of educational activity. The lack of motives of the learning inevitably leads to decrease in progress, degradation of the personality. Thus it is significant to research of pedagogical systems motivation models.

Among modern methods of a research of pedagogical systems special position is held by methods of mathematical and simulation (computer) modeling. This means that the real pedagogical system is replaced with abstract model − some idealized object has the most essential properties of the studied system. At the same time the behavior of model is investigated by using mathematical methods [11], [12] and by computer simulation [13], [14], [15]. The last means that the creation of the computer program which behaves like the teacher-pupils system and conducting the series of experiments at different parameters, initial conditions and external influences. The high speed of modern personal computers allows you to process large amounts of information and quickly carry out computer simulation. Changing the initial data and model parameters make possible to investigate ways of development of a system, to define its status at the end of training. This is the advantage of this approach in comparison with the method of qualitative analysis. The computer models considered in the present work can be used when carrying out a pedagogical experiment is impossible or results are negative. The logicality and the formality, reproducibility and specificity of the turning-out outputs, favorably, distinguishes the method of simulation modeling from "a method of qualitative reasoning".

The application of active forms and methods of teaching in pedagogical process is the most perspective way in improvement of preparation of the modern future teacher. And the leading place among them is taken by modeling and solving of the pedagogical situations close to professional activity. One of methods of a research of complex systems consists in creation of a simulation model and studying of its functioning under different conditions. Its application in didactic researches allows to create the simulation models corresponding to a specific situation and determine how the learning outcome depends on parameters of a system, initial conditions and external influences. This approach has certain advantages in comparison with "method of qualitative explanations": computer models are logical, the turning-out results have statistical stability, are more objective and rigidly connected with the conditions and restrictions imposed on model.

2. Related works

In the field of pedagogical modeling worked such authors as Konovalov S.V., Kozyreva O.A. [1, 2], Berezyuk Yu.V. [3], Salnikova L.V., Svinarenko V.G., Zubanov V. P., etc.

In their works Konovalov S.V. and Kozyreva O.A. define the concept of pedagogical modeling as a method of a pedagogical research and a result of evolution of a pedagogical thought in the formation student's identity, a tool of creating pedagogical innovations and pedagogical constructs, technologies and techniques, forms and the other pedagogically caused structures, determinations of functions and pedagogical conditions, trends and limitations and other components of scientific search in modern pedagogy.

Berezyuk Yu.V. [3] defines the method of simulation modeling of classes as a solution of problematic and psychological-pedagogical, pedagogical tasks, and mainly for the formation of practical skills (competencies). The author believes that a future teacher should get a concrete idea of the essence of his future activity by studying the methodological foundations and categories of scientific pedagogy, psychological patterns of personality development and formation, patterns of age-related

anatomical and physiological development of a person and many other equally important issues, without which it is impossible to design, build and correct the pedagogical process. Modeling is carried out according to the "synthesis-analysis-synthesis" scheme. The course of thinking in modeling can be represented in the following sequence: under the influence of the information given for assimilation, a person's mental activity begins, aimed at its assimilation.

Researcher Svinarenko V.G. formulates pedagogical modeling as a research method in the system of scientific research on pedagogy [4] and which is method of producing innovative practice tools, reflecting the specifics and possibilities of the determination and the solution of problems of personal development in the system of modern education. Modeling as a research method in the professional training of teachers defines ideal products. The methodical developments, manuals, textbooks, electronic dictionaries, digital libraries and other electronic resources opening setting and a solution of problems of personal development of the modern education studying in a system are the most popular. They reveal the formulation and solution of problems of personal development of a student in the system of modern education. At their modeling it is possible to select modeling of systems of the principles of pedagogical interaction, situational verbal self-expression and the holistic construction of various pedagogically caused phenomenon and phenomena, processes and procedures, mechanisms and functions.

The problem of simulation modeling of training activity based on the numerical solution of differential equations has been repeatedly discussed by different researchers such as Kudryavtsev V.B., Vashik K., Strogalov A.S., Plotinsky Yu.M. [5],[6], [7]. Let us consider the continuous model of training consisting of one-component learning model, a multicomponent model of training and the generalized learning model. Mayer R.V. [8] formulated the principles forming the basis of a one-component learning model:

1. Information (knowledge) given pupils is set of equal unrelated elements which number is proportional to its quantity. All elements of a training material are equally easy to remember and are forgotten at the same speed.
2. The learning process is reduced to the assimilation of knowledge and forgetting. Speed of change in the amount of knowledge is equal to the assimilation speed sum.
3. The time of assimilation of one element of a educational material is much less than the duration of training.
4. Speed of increase in knowledge is proportional to the product of the student's level of knowledge and motivation, i.e. the more a student knows, the easier it is for him to assimilate new knowledge due to the associative connections formed with the existing ones. On the other hand, the lower the motivation of the student, the less effort he spends and the lower the speed of increasing knowledge.
5. The student's effort of F (motivation of M) is directly proportional to the difference between the level of requirements U and the level of knowledge Z: $F = M = k(U - Z)$.
6. Speed of a forgetting is proportional to amount of knowledge which is available for the student: $dZ/dt = -\gamma Z$.
7. Based on the above considerations, we obtain that the speed of increase in knowledge is expressed by the equation:

$$\frac{dZ}{dt} = \alpha F Z^b - \gamma Z \qquad (1)$$

where α and γ − coefficients of learning and a forgetting of a particular pupil, and b depends on influence of the existing knowledge on the assimilation of new information.

The author concludes that at first pupils are offered relatively simple tasks when they master them − more difficult tasks, then even more difficult, etc. In order that the level of knowledge to grow, it is necessary to ensure in a not really big gap between Z and U. Too sharp increase in the level of requirements (complexity of the studied material) leads to the decrease in motivation and lowering of level of knowledge due to forgetting. If you first offer difficult tasks (level of requirements of U is very high), and then simple, then training will not happen. So, in order to optimize the educational process it is necessary to select thus the level of requirements (complexity of the tasks offered pupils) in such a way that a high motivation for learning is maintained.

It is known that process of assimilation and memorization of the given information consists in establishing associative links between the new and available knowledge. As a result, the acquired knowledge becomes stronger and is forgotten much more slowly. Multicomponent learning model can be reduced to such type of a system of equations [9, 10]:

$$\begin{aligned} dZ_1/dt &= k\alpha_1(U-Z)Z^b - k\alpha_2 Z_1 - \gamma_1 Z_1 \\ dZ_2/dt &= k\alpha_2 Z_1 - k\alpha_3 Z_2 - \gamma_2 Z_2 \\ dZ_3/dt &= k\alpha_3 Z_2 - k\alpha_4 Z_3 - \gamma_3 Z_3 \\ dZ_4/dt &= k\alpha_4 Z_3 - \gamma_4 Z_4 \end{aligned} \quad (2)$$

where $U-$ the level of requirements imposed by the teacher equal to the reported knowledge of Z_0, $Z-$ total knowledge, Z_1- the most "fragile" knowledge of the first category with high coefficient of a forgetting γ1, and Z_4- the strongest knowledge of the fourth category with low $\gamma_4(\gamma_4 < \gamma_3 < \gamma_3 < \gamma_1)$. Assimilation coefficients αi characterize by a speed of transition of knowledge $(\mathrm{i}-1)-$ th categories in knowledge $\mathrm{i}-$ th category. While the training is taking place, $k=1$ and when it stops $k=0$. If the increase of knowledge of the pupil is significantly less than their total quantity, then $b=0$. Forgetting coefficient $\gamma = 1/\tau$, where $\tau-$ time during which the amount of knowledge $i-th$ of category decreases in $e = 2.72...$ times. The training result is characterized by total level of the acquired knowledge of $Z = Z_1 + Z_2 + Z_3 + Z_4$ and coefficient of "durability" of $Pr = (Z_2/4 + Z_3/2 + Z_4)/Z$. When studying one topic at first the level of knowledge of Z grows, then there is an increase in a share of "strong" knowledge of Z_4 and Pr durability increases.

In his work, Mayer R.V. proposed a unique generalized learning model, as a result of which the "strong" knowledge of Z_2 during the learning process, and after that it is practically not forgotten. "Fragile" knowledge $Z_1 = Z - Z_2$ is forgotten much faster.

The given multicomponent learning model takes into account the different complexity of the topics studied and the change in the student's performance during the school day [16]. Let $Z-$ the total knowledge of the pupil, Z_1- the most "fragile" knowledge of the first category with high coefficient of a forgetting γ_1, Z_2- knowledge of the second category with smaller coefficient of a forgetting γ_2, …, and Z_n- the "strongest" knowledge $n-th$ categories with low $\gamma_n \cdot (\gamma_n > y_2 >_{\ldots} > \gamma_n)$. Assimilation coefficients α_i characterize speed of transition of knowledge $(i-1)-th$ categories in stronger knowledge $i-th$ of category. So far there is a training, $o=1$ and when it stops,$o=0$. Forgetting coefficient $\gamma = 1/\tau$, where $\tau-$ time during which the amount of knowledge $i-th$ of category decreases in $e = 2.72\ldots$ time. Training is characterized not only amount of the acquired knowledge $Z = Z_1 + Z_2 +_{\ldots} + Z_n$, but also coefficient of "durability":

$$Pr = (Z_2/2^{n-2} +_{\ldots} + Z_{n-1}/2 + Z_n) \quad (3)$$

When studying one subject at first the level of knowledge of Z grows, then there is an increase in a share of strong knowledge of $Z_n$and Pr durability increases.

Let initial efficiency of the pupil $r_0 = 1$.

At any moment $Z(t) = Z_1(t) +_{\ldots} + Z_n(t)$. During training $(o=1)$:

$$\begin{aligned} &F = U - Z > 0, \\ &r = r_0/(1 + \exp(k1(P - P_0)), \\ &P = k_2 \int_{t_0}^{t} (1+S)(U-Z)dt \\ &dZ_1/dt = r(1-S)\left(\alpha_1 F Z^b - \alpha_2 Z_1\right) - \gamma_1 Z_1, \\ &dZ_2/dt = r(1-S)(\alpha_2 Z_1 - \alpha_3 Z_2) - \gamma_2 Z_2 \ldots \\ &dZ_т/dt = r(1-S)\alpha_т Z_{n-1} - \gamma_n Z_n \end{aligned}$$

The student's working capacity gradually decreases during the lesson, and during breaks it increases to a value that gradually decreases during the day due to accumulated fatigue [16].

So, the method of simulation modeling allows us to analyze various situations encountered in pedagogical practice, and to study the influence of certain factors on the learning outcome.

3. The Problem Statement

The purpose of this work is a mathematical description of the process of teaching students, taking into account such parameters as the level of competence, the level of motivation, the level of perception of the material. The method of random numbers is used for the evolution of parameters in time, as well as a hypothesis about the dependence of the growth of competencies on other parameters. Several of these parameters have been tested. It is necessary to develop an algorithm and software for numerical experiments on the influence of teaching parameters on changes in students' competence over time and to assess the plausibility of the teacher's influence on these parameters.

4. Results and Discussion

Each student is characterized by motivation of M, level of competence C and coefficient of perception of A which characterizes mental abilities of the student and considers loss of information on the forgetting. It is also necessary to characterize influence of the teacher. The teacher is characterized by the share of the transferred information ΔE and influence on motivation ΔM. We made the assumption that the gain of competences dC at each stage is directly proportional to the current competences of the student and his motivation.

$$dC = k \cdot \Delta E \cdot M \cdot A \cdot C \qquad (4)$$

where $k -$ the constant of proportionality.

Process of training is assumed to be broken into the set of small stages, on each of which assessment of competences is possible. Daily assessment of independent work of the student or test results can be such stage. At this stage we will assume that this assessment is objective. Also, we will consider that the motivation of the student changes depending on many factors. Therefore, we will consider that it changes accidentally on normal distribution with dispersion $\Delta M/2$. Thus, we receive model of educational process:

$$C_{t+1} = C_t + k \cdot \Delta E \cdot M \cdot A \cdot C_t,$$

$$M_{t+1} = M_t + gaus(\Delta M, \Delta M/2). \qquad (5)$$

where $gaus(\Delta M, \Delta M/2)$ − normally distributed pseudorandom number with the median ΔM and dispersion $\Delta M/2$.

The algorithm of the modelling is the M, C, A parameters for students are set accidentally, then formulas (4) are applied consistently to t from $0\ to\ T$. According to this algorithm the program on Delphi was worked out (Fig. 1).

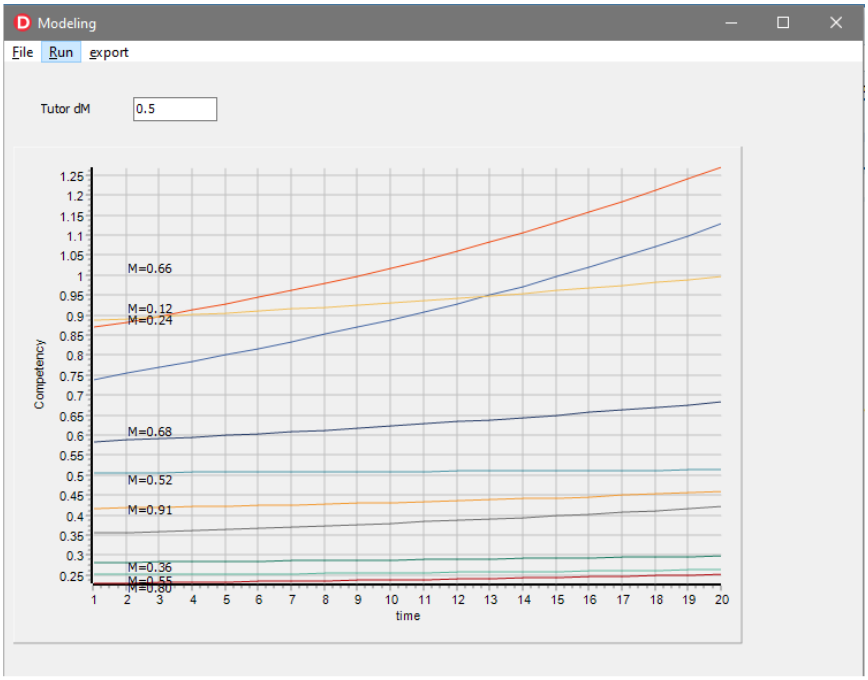

Figure 1. Interface of the program of modeling.

Now we will consider as the motivation of the teacher influences group of students with accidental parameters

4.1. Case of high motivation

Let us modelling the case when the teacher every time makes positive impact on motivation of students. Let us start modeling with $\Delta M = 0.5$.

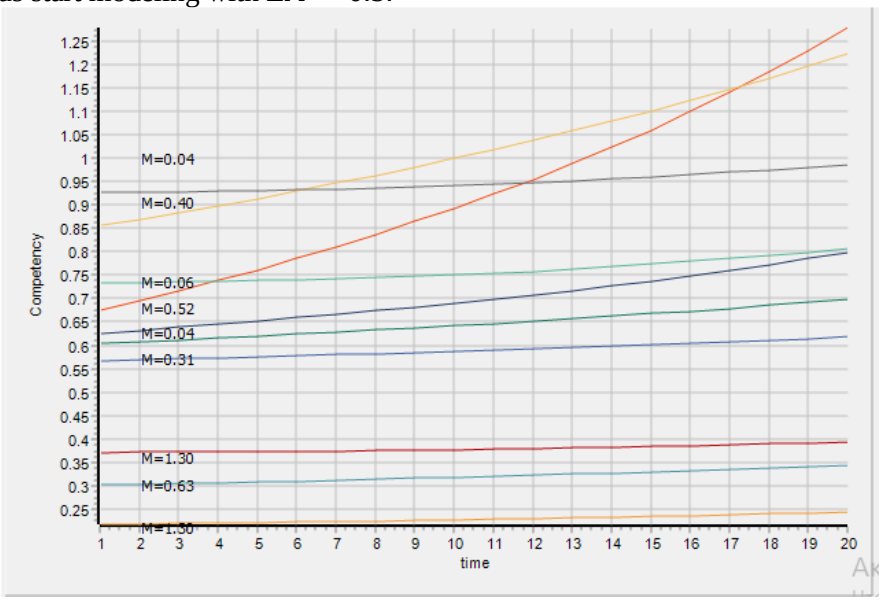

Figure 2. Modeling results. Positive motivation $\Delta M = 0.5$

And also, with $\Delta M = 1$

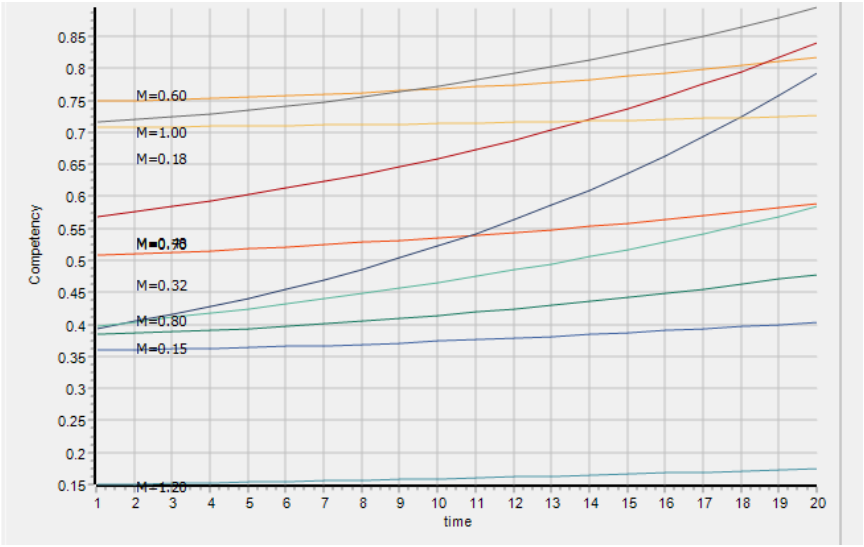

Figure 3. Modeling results. Positive motivation $\Delta M = 0.5$.

It is visible that most of students, even with initially low motivation began to show growth of assimilation of knowledge, even starting with small to stimulation of their motivation.

4.2. Case of low motivation

Let's model the case when the teacher regularly demotivates students. Let's start modeling with $\Delta M = -0.5$

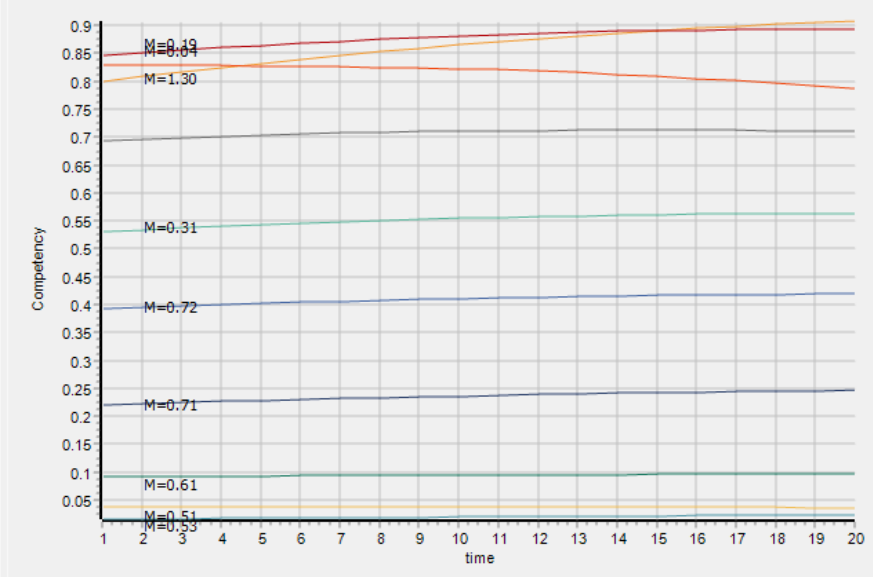

Figure 4. Modeling results. Negative motivation $\Delta \boldsymbol{M} = -\mathbf{0}.5$

And also, with $\Delta M = -1$

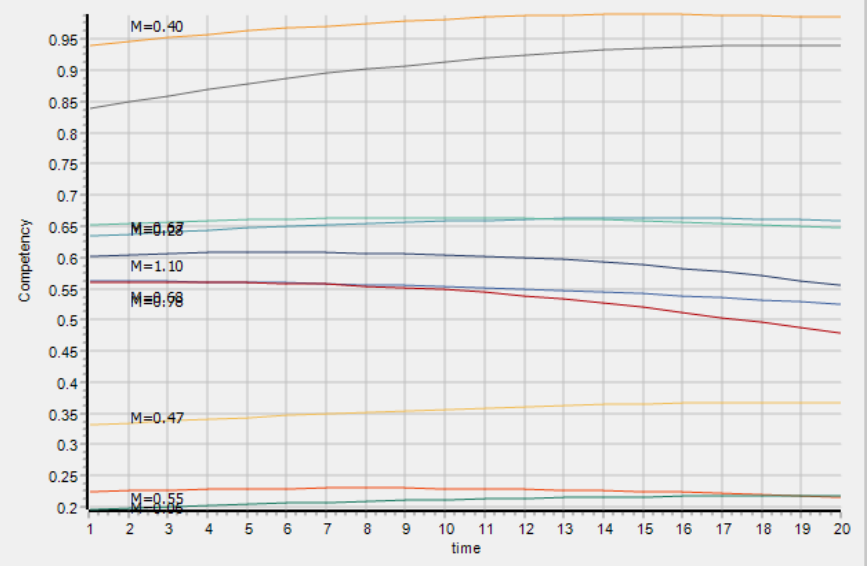

Figure 5. Modeling results. Negative motivation $\Delta M = -1$

It is visible that if the teacher does not create premises of motivation, then the level of knowledge at best does not grow, and most often falls.

Motivation plays a key role in our learning. According to the study, motivation has a greater impact on our math performance than our IQ level.

Specifically, the researchers found that IQ was closely related to student performance in math, but only in the early days of competition in this area. Students' high motivation and skills were the most significant factors in the successful development of higher math skills. Students with good academic performance were intrinsically motivated and able to use skills such as explanation, synthesis, and search for connections with previously acquired knowledge. They avoided memorization by memorizing and showed more noticeable progress in the field of mastering mathematics, in contrast to those who did not feel intrinsically motivated. In contrast, students' intelligence levels are not related to their accomplishments in mathematics.

Why is it so important to keep children motivated to learn?

- Motivation increases effort and perseverance in completing tasks;
- Our motivation gives the green light to initiative;
- Motivation improves cognitive ability;
- Finally, motivation improves overall performance.

Various studies of the structure of human activity invariably emphasize the need for a motivation component in it. Any activity proceeds more efficiently and gives high-quality results, if at the same time the personality has strong, bright, deep motives that cause the desire to act actively, with full dedication, to overcome inevitable difficulties, unfavorable conditions and other circumstances, persistently moving towards the intended goal. All this has a direct bearing on educational activities, which are more successful if students have a positive attitude towards learning, if they have a cognitive interest, the need to acquire knowledge, skills and abilities, if they have a sense of duty, responsibility and others. motives of learning.

5. Conclusion and Perspectives

Thus, the prime model considering motivational influence of the teacher is received created the algorithm and the program simulation, results of simulation influence of motivation of the teacher on motivation of the student are received. As it appeared, the motivation of students is decisive factor development of competences.

One can propose several directions for the development of the model:

- Predicting the effectiveness of training by direct use of the model. In this case, the parameters of the model are set explicitly, assuming that the values $C(t = 0) = C_0$ for each student and his

motivation are known. On the other hand, if two consecutive rating of the students' competence $C(0)$ and $C(\Delta t)$ are known then define value $\gamma_i = k \cdot M_i \cdot A_i$and knowing the information feed rate of the ΔE from formula (3), we obtain

$$\gamma_i = \frac{C_i(\Delta t) - C_i(0)}{C \cdot \Delta E}$$

And then, by numerical integration over time, we get an estimation of effect of education process.

- Evaluation of the effectiveness of teaching methods by restoring the parameters of the model based on the results of education process. By solving the inverse problem, one can obtain estimates for the sign of the derivative ΔM. Taking advantage of the fact that the $A \cdot k\Delta E > 0$ will evaluate the sign of the dM using the expression

$$\mathrm{dM} \sim \frac{dC(t+1)}{C(t+1)} - \frac{dC(t)}{C(t)}$$

and group average value

$$< \mathrm{M} >= \sum_i \left(\frac{C_i(t+1) - C_i(t)}{C(t+1)} - \frac{C_i(t) - C_i(t-1)}{C(t)}\right)/N$$

Having received the ΔM sign, we can assert that with positive values, the education process is successful and students are motivated, and with negative values, it is necessary to change the teaching methods, because demotivating of students, as shown by numerical experiments in the present work, have a result they do not accept the material.

- Bayesian extrapolation method. The authors see further development of modeling methods in the use of probabilistic methods of competencies. That is, the value C is reviewed as a probabilistic estimation of the fact that a student is competent, and the process of his attestation participates in the iterative procedure of values refinement by the Bayesian methods. So, having obtained the experimental data of the estimation of competence, one can predict the further development of the student's competence in terms of the conditional probability built on the results of his rating. Thus, using of the Bayesian method based on this model can compensate for subjective errors in estimation the student's competence and academic results.

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