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Computer Model of the Physical Facts Learning

Dr. Robert Valerievich Mayer
Professor of the Chair of Physics and Didactic of Physics, The Glazov Korolenko State Pedagogical Institute, Glazov, Russia
Corresponding Author E–mail: robert_maier@mail.ru

Abstract

When pupil studies physics at school in their consciousness the system of empirical knowledge is forming. The use of methods of mathematical and computer modeling for studying of this process is discussed. The offered three–component model basis on division of the physical facts into three categories: 1) the facts established in everyday life; 2) the facts, which the pupil can experimentally establish at a physics lesson; 3) the facts which are studied on the theoretical level (speculative or ideally). The graphs of dependence of the factual knowledge from time are given.

Keywords: computer models, didactics, mathematical methods, pedagogics, pedagogical examination, theory of training.

Introduction

The important direction of development of the modern training theory consists in studying of didactic systems by method mathematical (Roberts 1986; Hunt 2007; Dobrynina 2009) and imitating (or computer) modeling (Dorrer & Ivanilova 2007; Kudrjavcev *et al* 1996). The essence of the modeling method is that the real pedagogical system is replaced with abstract model, – some idealized object which behaves like the studied system. Such model can be system of logical rules, the mathematical equations or the computer program allowing to make a series of experiments at various parameters, entry conditions and external influences. If we are changing initial data and parameters of model, then it is possible to investigate ways of development of system and to define its state at the end of training (Atkinson *et al* 1969).

Now the discrete and continuous computer models of training which are based on automatic approach and the solution of the differential equations (Leont'ev & Gohman 1984; Mayer 2013; Novikov 1998) are known. Sometimes the multi–agent models at which each pupil is replaced with the program agent functioning irrespective of other agents are used (Ivashkin & Nazojkin 2011). Also there are imitating models using Petri's networks, genetic algorithms, matrix modeling. In these case there is the problem of the computer model coordination with distribution of educational information and results of testing. It is necessary to set certain numerical values to the pupil's parameters, the transfer speed of information, level of teacher’s requirements during training; only in this case the model will describe a real situation.

Important component of the physics course is the empirical knowledge gained as result of observation and experiments. Elements of empirical knowledge are the generalized facts and empirical laws. The purpose of the real work is as follows: 1) creation of mathematical and computer model of assimilation of empirical knowledge at physics lessons at the Russian schools; 2) coordination of model with distribution of educational information in a school course of physics and the testing results of the school graduates.

1. Division facts on three categories

The studying method of this or that fact are depends from possibility of its experimental establishment in everyday life and in the school. It is obvious that almost all facts established in everyday life can be studied experimentally at physics lesson. Therefore we allocated three following categories of the facts differing on a way of their studying by pupils (Mayer 2014):

1. The facts of the first category which after their experimental studying at school average pupil can establish in everyday life (existence of Archimedes force, electric current, light refraction).

2. The facts of the second category which the pupil can't experimentally establish in everyday life, however they can be experimentally proved on the physics lessons (photo–effect, polarization of light, refraction of electromagnetic waves).

3. The facts of the third category which can't be experimentally established in the conditions of training and their studying it is carried out on the speculative level (thermonuclear reaction, relativistic delay of time, Michelson’s experiment).

It is obvious that assimilation durability and the forgetting speed of the facts of first, second and third categories are various. It is possible to assume that the facts of the first category are easier acquired and more slowly forgotten as they are included in activity of the pupil who continuously faces them, "rediscovering" them. The facts of the second category are forgotten quicker, than the first, but not so quickly, as the third category facts because the pupils observed or performed the corresponding experiments on physics lessons. The forgetting speed of the third category facts is highest, because the pupils studied them speculative (or ideally) and seldom use this knowledge in their activity.

2. Mathematical model of assimilation of empirical knowledge

We will break process of training into small intervals and will consider that in each such interval the speed of information transfer to the pupil is constant: $³ = dI / dt = const$. Let us consider, that all educational information is acquired by pupil. The speed of increase in the pupil's knowledge Z is equal to the sum of the speed of training and speed of forgetting $-¥ \cdot Z$: $dZ / dt = ³ - ¥ \cdot Z$. Here $¥$ is the forgetting coefficient. Considering that at the time of the beginning of training t_0 amount of the pupil's knowledge is $Z(t_0) = Z_0$, we get:

$$\int_{Z_0}^{Z} \frac{dZ}{Z - ³ / ¥} = -¥ \int_{t_0}^{t} dt .$$

From this it follows that amount of the pupil's knowledge in a timepoint t is equal to:

$$Z(t) = \frac{³}{¥}(1 - e^{-¥(t-t_0)}) + Z_0 e^{-¥(t-t_0)} .$$

Let in an initial timepoint $t_0 = 0$ amount of knowledge of the pupil equally to Z_i and $² = 1$ year. Amount of knowledge of the pupil at the end of $(i+1)$–th academic year:

$$Z_{i+1} = Z_i e^{-¥²} + \frac{³_{i+1}}{¥}(1 - e^{-¥²}),$$

where Z_i – the level of knowledge at the end of i–th of year, $³_{i+1}$ – the transfer speed of knowledge in $(i+1)$–th year. This equation allows to calculate sequentially the amount of the pupil's empirical knowledge at the end of 1, 2, …, the 11–th years of training in the school.

As amount of knowledge of the facts of j–th academic year equally to the sum of the knowledge acquired in 1, 2, …, i, … , j–th classes which partially forgotten during $(j-1)$, $(j-2)$, …, 1, 0 years respectively, so we have:

$$Z_j = \sum_{i=1}^{j} \Delta Z_i e^{-¥(j-i)²} = \sum_{i=1}^{j} \frac{³_i}{¥}(1 - e^{-¥²}) e^{-¥(j-i)²} ,$$

where $\Delta Z_i = (³_i / ¥)(1 - e^{-¥²})$ – the quantity of knowledge acquired in i–th class, the multiplier $e^{-¥(j-i)²}$ considers the forgetting within $(j-i)$ years, $² = 1$ year – training time in one class.

Use of this model for research of knowledge assimilation demands the accounting of dependence of the forgetting time from category of the facts. Considering that forgetting coefficients of the facts of the first, second and third categories and their transfer speeds are respectively equal to $¥_1$, $¥_2$, $¥_3$ and $³_{i1}$, $³_{i2}$, $³_{i3}$, where $i =$ 1, 2, …, 11 – number of a class, after transformations we receive:

$$Z_j = \sum_{k=1}^{3} Z_{jk} = \sum_{k=1}^{3}\sum_{i=1}^{j} \frac{3_{ik}}{\text{¥}_k}(1-\exp(-\text{¥}_k{}^2))\exp(-\text{¥}_k(j-i)^2),$$

where Z_{ik} – the amount of the pupil's knowledge corresponding to the facts of k –th category at the end of j –th class. We will enter assimilation coefficient of empirical knowledge K_j as the relation of factual knowledge Z_j into j –th class to total empirical information: $K'_j = Z_j / I_j$. Thus the quantity of the given information is equal:

$$I_j = \sum_{k=1}^{3}\sum_{i=1}^{j} 3_{ik}{}^2 .$$

3. Results of computer modeling

As a result of the content analysis of the Russians physics textbooks the transfer speed of empirical knowledge in different classes in fact/year were determined. For the purpose of determination of the forgetting coefficients the testing of about 100 students of first course of the Glazov State Pedagogical Institute was held. It allowed to determine the level of knowledge by these students of 50 educational facts (on 10 from each section of physics) and estimate the assimilation coefficients K of the facts of various categories as the relation of number N of the asked questions to number n of the correct answers: $K = n / N$.

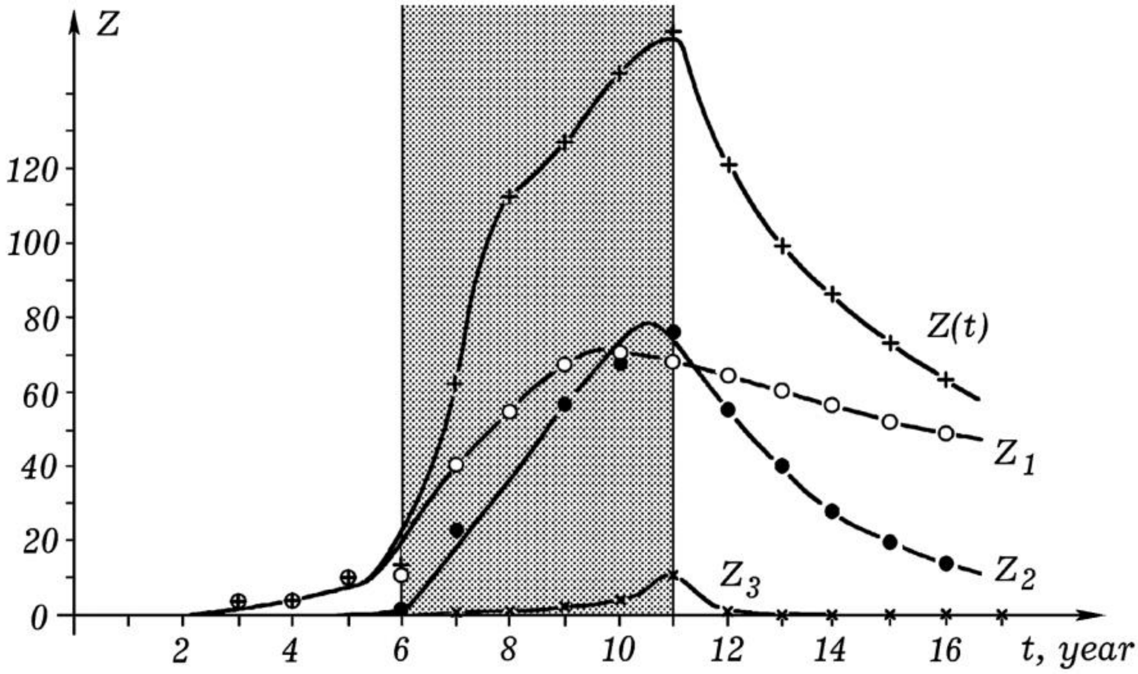

Fig. 1. Dependence of factual knowledge of various categories from time.

The problem of coordination of mathematical model with the testing results is reduced to determination of such values ¥_1, ¥_2, ¥_3 at which the assimilation coefficients of empirical knowledge K'_k for the facts of various categories predicted by model, are closest to the corresponding values K_k received at testing. For this purpose we used the method of the smallest squares consisting in minimization of the sum:

$$S = \sum_{k=1}^{3} (K_k - K'_k)^2 = \min .$$

Results of modeling are present on fig. 1. It is visible that the facts of the third category studied at purely speculative level are most quickly forgetting. Their forgetting coefficient $¥_3 \approx 1{,}5$ 1/year, period of the half information forgetting is $T_3 = \ln 2 / ¥_3 = 0{,}46$ years. The facts studied with using the physical experiment are forgetting slightly more slowly: $¥_2 \approx 0{,}49$ 1/year, $T_2 = \ln 2 / ¥_2 = 1{,}4$ year. The first category facts, which the pupil can establish experimentally in everyday life are forgetting even more slowly: $¥_1 \approx 0{,}090$ 1/year, $T_1 = \ln 2 / ¥_1 = 7{,}7$ 1/year.

The analysis of the received graphs and testing results allows formulate the following regularities of formation at pupil's consciousness the system of empirical knowledge:

1. In process of their studying the level of knowledge of the first category facts consisting daily experience of pupils increases, and after the end of training remains almost invariable.

2. After studying the levels of knowledge of the second and third category facts which are not consisting pupil's daily activity decreases due to forgetting.

3. The forgetting speed of the second and third category facts is more, than to a lesser extent their studying basis on the activity of pupils connected with observations and performance of educational experiences, their theoretical (speculative) studying.

Conclusions

In article application of mathematical and computer models for studying of the empirical knowledge assimilation by pupil is analyzed. The three-component model which basis on division of the physical facts into three categories is offered. To determinate the forgetting coefficients of the facts of the first, second and third categories the coordination of imitating model with distribution of empirical information in a school course of physics and results of testing is carried out. The graphs of dependence of empirical knowledge from various physics sections and categories of facts from time are received. The above described regularities explain why graduates of school usually remember the facts of the first category well enough, but satisfactory – the facts of the second category and rather poor – the facts of the third category.

References

Atkinson R; Baujer G and Kroters Je 1969 Vvedenie v matematicheskuju teoriju obuchenija [Introduction to the mathematical theory of training]. Moscow: Mir. 486 p

Dobrynina N F 2009 Matematicheskie modeli rasprostranenija znanij i upravlenija processom obuchenija studentov [Mathematical models of the spread of knowledge and learning management students]. In: Basic research. N 7

Dorrer A G and Ivanilova T N 2007 Modelirovanie interaktivnogo adaptivnogo obuchajushhego kursa [Modeling of interactive adaptive course of learning]. In: Modern problems of science and education. N 5

Hunt E 2007 The Mathematics of Behavior. New York, Cambridge University Press. 346 p

Ivashkin Ju A and Nazojkin E A 2011 Mul'tiagentnoe imitacionnoe modelirovanie processa nakoplenija znanij [Multi–agent simulation of the process of accumulation of knowledge]. Software products and systems. N 1. pp. 47-52

Kudrjavcev V B; Vashik K; Strogalov A S; Alisejchik P A and Peretruhin V V 1996 Ob avtomatnom modelirovanii processa obuchenija [On the automaton model of the learning process]: Discrete Mathematics. T. 8. Vol. 4. pp. 3-10

Leont'ev L P and Gohman O G 1984 Problemy upravlenija uchebnym processom: Matematicheskie modeli [Problems Training Management: Mathematical model]. Riga. 239 p

Mayer R V 2013 Mnogokomponentnaja model' obuchenija i ee ispol'zovanie dlja issledovanija didakticheskih sistem [Multicomponent model of training and its use for research of didactic systems]. In: Fundamental'nye issledovanija: Pedagogicheskie nauki, N 10, pp. 2524-2528

Mayer R V 2014 Kiberneticheskaja pedagogika: Imitacionnoe modelirovanie processa obuchenija: monografija [Cybernetic pedagogics: Imitating modeling of process of training: monograph]. Glazov, Glazov. gos. ped. in–t. 141 p

Novikov D A 1998 Zakonomernosti iterativnogo nauchenija [Regularities of iterative learning]. Moscow, Institut problem upravlenija RAN. 77 p

Roberts F S 1986 Diskretnye matematicheskie modeli s prilozhenijami k social'nym, biologicheskim i jekologicheskim zadacham [Discrete mathematical models with annexes to social, biological and ecological tasks]. Moscow: Nauka. 496 p