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On the meaning of the features in learning curve measurements by MGKR

Introduction

Chris Crawford defines a game as an interactive, purposeful, social activity [Crawford, 2003]. A study published in New York Times, claims that the goal of the game is not a physical training but mental preparation for obstacles a person's life can encounter, because the game develops certain specific parts of the brain [Henig, 2008]. The above mentioned obstacles can be overcome by learning as well, but this is not so entertaining form. A significant difference between learning and game is the fact that the game provides some form of immediate reward that can fill higher needs of individual.

In the first half of the 20th century Abraham Maslow compiled a hierarchy of human needs [Maslow, 1954, s. 236]. After filling the biological needs individuals focus on meeting secondary and higher needs (just like needs for success).

The game has clear targets and provides immediate, easily obtainable and understandable reward, not only at the end of the game, but also in its course (obtaining points, rank, or abilities). This is the element, which often binds a student to the game. [Hejdenberg, 2005]. This is the feature that can make learning more attractive. We are not talking now about learning game, but the immediate feedback in learning.

Model of growth of knowledge

When student solve a physical problem, it is very important that he knows, that the steps what he has done are correct or incorrect in the process of solution. It is very important to evaluate result of student’s activity (preferably positively) and, in such a way, he could achieve self-confidence and motivation for further activities.

Numerous experiments were realized, demonstrating the relationship between success solution of the physical tasks and the number of repetitions.

This percentage (relative success) increased in case when were no change of level of difficulty of solved physical problems. Students receive immediate feedback that rewards the right solution and it does not award the wrong one (after the solution in feedback it has to be immediately explained how the task is properly handled). This dependence can be described by curve of knowledge growth (represented by the relative success of student’s solutions) on the number of repetitions. Mathematically, the curve can be interpreted on the basis of a model of the knowledge growth by the number of repetitions. The model that we use in the experiments is the model of knowledge growth by repetition (MGKR), built on theory of ENKI (Efficacy Norm of Knowledge Increase), which is described in detail in [Lacsný 2005].

Discussed model shows also the dependence of dynamics of the growth of knowledge on the number of autonomous units. The probability $P(n;Na)$ of the N_a autonomous structures completion in n repetitions is then

$$P(n; N_a) = (1 - q^n)^{N_a}$$

where $(1 - q)$ is the probability that one autonomous structure will be complete by one repeating. The parameter q is interpreted $q = e^{-\alpha}$ [Lacsný, 2005].

This model is able to correctly interpret the increase of knowledge in the case of less complex cognitive processes (like it can interpret model based on Hebbian rules described in [Hassan, 2009]), but also in case of more complex cognitive processes (like it is able to describe model built by Gamble described in [Błasiak, 1996] and [Gamble, 1986]), as it is mentioned in [Benko, 2012]. It is MGKR model, which uses the number of repetitions as independent variable. Other mentioned models are based on the increase of knowledge depended on the time. We note that the model assumption is necessity of repetitions implemented in certain time windows, the length of which may vary in reasonable intervals.

Feedback allows detection of an error in pupil´s solutions. Experiment realized on primary school pupils can demonstrate the importance of this feedback. Two groups of pupils (of the same age) were tested using tasks of "serial and parallel connection of resistors" topic. It was given a feedback to the control group (N=58). Feedback noted the correctness of task solution in the form of short answers (correct solution / incorrect solution). It was given an extended feedback to experimental group (N=52). This feedback has presented correctness of task solution with a detailed explanation of the correct procedure for solving tasks. We have shown that the experimental group reached increase of learning curve, but there was no learning curve in the control group data (Fig. 1). Parameters, which describe learning process in learning curve, have reached negative values. This points at the fact that learning curve can´t be graphically represented with real coordinates [Benko, Rosiek, Teleki, 2013].

We can subjectively decide if the difficulty of physical tasks changes. In this paper we establish that the term "unchanged difficulty" means single structure tasks which perform a constant number of observed features (or new features). The observed feature is a comprehensive knowledge base unit which the subject of the content of solved tasks. It will increase the relative percentage in the case of repeating task solutions containing one observed feature. The shape of increasing curve may be determined by the complexity of the cognitive processes used in task solution.

If a new task requires the use of more complex cognitive process in terms of Bloom's taxonomy, there are restructured neural networks in the brain, and the knowledge (in terms of Piaget's theory) must consolidate the newly created structure (Fig. 2). This fact has been verified by several experiments realized on university students (N=863). Their goal was to solve several similarly focused and structured tasks (mechanical energy topic) and consequently several tasks where they had to use additional knowledge (mechanical momentum). Learning curve fell sharply when there were changes in the tasks. Afterwards learning curve increased again, but in altered form of shape.

The experiments realized at Constantine the Philosopher University were aimed on knowledge growth by repeating several tasks of capacitors composing topic (N=12). Two independent features were observed (Fig. 3). We ensured that these two features were observed independently using the so called cascade evaluation method. Its principle is that each task is divided into parts that are evaluated separately. In our case, each task consisted of two parts. In the first part of the task the level of understanding cognitive process feature was observed and in the other part the level of application cognitive process feature was observed.

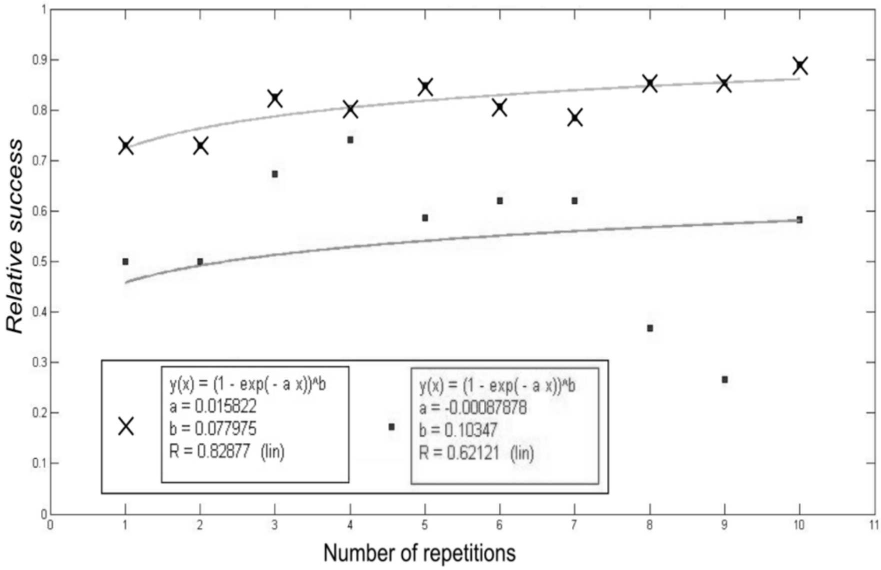

Fig. 1. Curves of knowledge growth in group with immediate feedback (marked x) and without feedback (marked with dots). Number of repetitions is on horizontal axis and relative success of pupils is on vertical axis

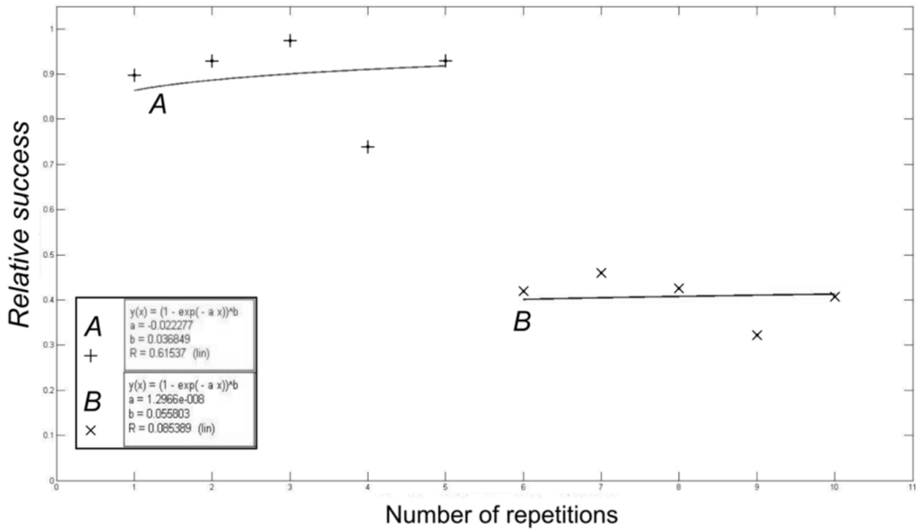

Fig. 2. Continuous learning curve. First part (curve A) is learning curve in test with one observed feature on the level of understanding cognitive process. Other part (curve B) is learning curve in test with two observed features (one of them just learnt)

Tasks were in the total set on an analytical level of cognitive process. Every solution attempt was followed by an explanation and presentation of correct solution. Another part of the task was thus solved on the bases of correct previous result. This allowed the evaluation of the second feature independently from the first one because the error is not transmitted. It has shown an increase of learning curve with shape of lower cognitive processes by evaluation of features individually. Every shown curve demonstrates the used cognitive process (Fig. 3 – curve A and B). General evaluation of the tasks (whether the task was solved correctly) pointed out that increase of learning in this case of cognitive processing is different, and the curve of knowledge growth has a different shape. This corresponds to the assumption of the model defined in [Benko, 2011]. Such a curve (Fig. 3 – curve C) corresponds to solving problems with the use of higher cognitive processes.

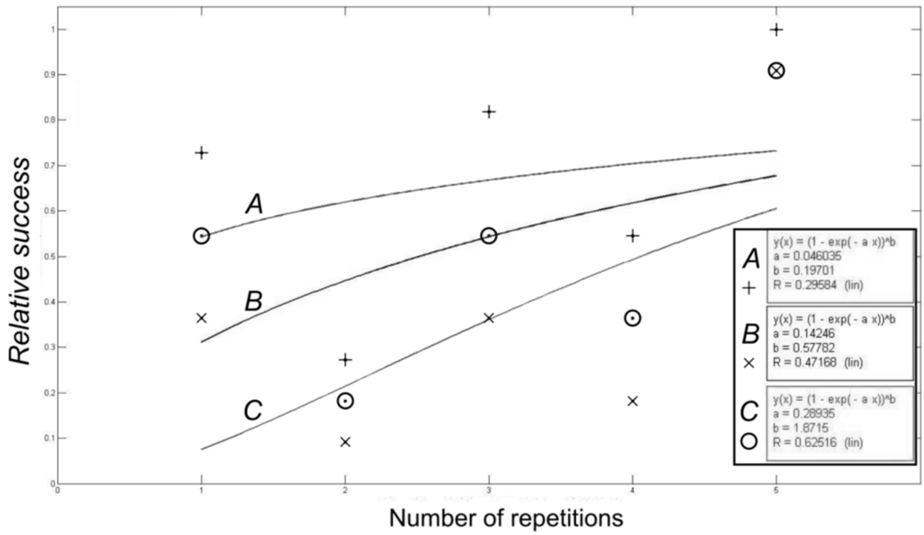

Fig. 3. Evaluation using a cascade method. Curves A and B are learning curves of separately evaluated features and curve C represents learning curve of observed features evaluated together

Conclusion

The ENKI model based on random processes in the neural network through the learning processes (were, indeed, the repetition plays crucial role) describes the learning process very well in comparison with the well-known Gamble's model and Hebbian rule.

Presented experiments have shown also that for the determination of the curve of knowledge growth by repetition it is crucial to take into account the number of observed features. Learning curve is different in case of one or more observed features, although the individual difficulty of the features may be the same. Learning curve varies by introducing a new observed feature in the testing and the introduction of several features in the tasks may significantly affect not only the learning curve but the efficiency of the teaching process in general.

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Website: http://www.primas-project.eu.

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