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Reflections on the Relationship Between Cybernetic Pedagogy, Cognitive Science & Language

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Abstract. Based on our previous educational researches we discuss whether it is possible to replace a human teacher with a virtual (machine) teacher, refereeing the hidden layers of doing so, as well as considering the technological possibilities currently available explain what this means in a society. For, an adaptation of current cybernetic into cybernetic pedagogy as cognitive modelling within a compounded educational system is proposed.

Keywords: *Learning process, cybernetic pedagogy, cognitive science, symbol models, connectionism, hybrid systems, programmed learning, learning algorithm, e-learning material, logics and language, science & society.*

An Introduction

On *Cognitive science*. A cognitive educator is the educator who uses *science of the mind* as a tool at his / her modelling of the teaching and learning process. Consequently one of the basic questions facing educators today has always been *How do we start improving the teaching / learning process*? Fortunately, we do not have to begin from scratch to answer such a complicated question. The experts recommend that one should start by

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defining the nature of thinking. Before we can make a better process, we need to know more about how people process information, how people think (Hus et al., 2011) New discoveries in the field of developmental cognitive science and neuroscience hold great promise for improving current teaching methods (Aberšek, 2013). It can be argued that teaching is something unique, unpredictable, and closely related to a person as an individual in society. Formal constants can be established for this individual, on the basis of which they are objectivised and formalised. By writing them down in the form of a mathematical model, conditions are created for the development of a *virtual teacher* or intelligent e-learning material.

On the presumption that there is a correlation between a human and a machine in the sense of a naturalist basis and a reductive path which brings us to it (Dreyfus, Dreyfus, 1986), we argue that it is possible, with certain limitations and simplifications, to create an intelligent autonomous system (programme, computer or android – a robot) capable of learning, adapting to new circumstances, and at the same time implementing critical self-evaluation (Bechtel, Abrahamsen, 2002; Bermudez, 2010; Aberšek, Bregant, 2012). Since a positive answer to the question *can the human mind and learning be formalised and reduced to the language of science* (Anderson, 2007) is essential for the success of our project, we will try to prove this by using revised cybernetic pedagogy and didactics.

On logics and language. Correlated problematic with teaching, pedagogy and cognitive sciences – even if here we do not have room to speech – is a) the logical scientific organization of theory (Nagel, 1961) and its presentation during lecturing, b) the scientific language used. It was remarked the paradox of the formalization of logic (Carnap, 1943) accordingly with to express axioms and to construct a *meta–discourse* about them, we should use the natural language, which is not–formalized; we cannot formalize it in advance, because we risk producing a regression to *infinitum*. Moreover, it is not natural to state the axioms of logics and then to consequently deduce all the rest from them (*Ibidem*). In fact, in everyday life that is never done. When we think, we usually proceed from temporary premises, and then introduce or remove logical elements of natural language. That is a natural inference, which can express both classical and non–classical logics (Prawitz, Melmnaas, 1968). In mathematical–classical logic, so–called *well–formed–statements* are assumed to be either true or false, even if we do not have a proof of either. In fact, from an inferential and classical logics system (e.g. a list of inferential propositions) one can only obtain a scientific dichotomy of hypothesis–these *free–from–self–contradiction* and among them, and a theory to be *scientific* must be testable, e.g., subject to *falsification* (Popper, 1959; Popper, 1963). Let us note that in that kind of system of reasoning, it is not possible to obtain *undecidable contents.* Particularly, if *undecidable* contents belong to a given principle of the theory, then we have an *out of the ordinary principle*. Thus, *what kind of pedagogical modeling are adequate to support a coherent teaching–learning, process where natural and scientific language are combined?*

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On Cybernetics and Cybernetic Pedagogy

Couffignal (1933) one of the pioneers of cybernetics, considered it "the art of ensuring the efficacy of action" and Wiener (1948) defined it as "the scientific study of control and communication in the animal and the machine". A less poetic definition describes it as the *science of dynamic time-dependent relations between the parts and a whole and the parts themselves*.

Cybernetics thus teaches us that life is both: a system and information, whereas it is presumed that a *machine is only a system that "feeds" on information*. If we turn a computer off, it will no longer be able to use the information stored in its memory, but it will still be a computer ready to work as soon as we turn it back on. Nevertheless, if we, for example, withhold food from a plant or an animal, it will quickly become an inert body that is dying since its structure coincides with the energy that feeds and transforms it, i.e. supplies it with information. Despite this, we will, further on in the article, on the basis of the fundamental findings in cybernetics look for and argue for similarities between natural and artificial intelligence with an emphasis on modern trends in cognitive science that swears by the connectionist approach to considering and creating "thinking machines"[1]; we believe this gives standard cybernetic pedagogy the possibility for further development. One of the artificial teacher's (computer system) main advantages is that it can prepare a specifically tailored curriculum (teaching system) for each student and, based on that, provide a correct evaluation of the individual's achievements. A question arise: *what kind of basic assumptions can we do in–between cybernetic and cybernetic pedagogy?*

Cybernetic Pedagogy

On our side, we try to check assumptions as *ad hoc* general principles of cybernetics and transfer them to an education system.

According to Frank and Mader (1971) it is possible to formalise or objectivise the teaching-learning process as a compounded educational learning algorithm *B* (i.e. a system connecting all the aforementioned elements in an indivisible whole) and express it as a mathematical function with the five main conditional variables:

$$B = f(Z, L, M, P, S) \qquad (1)$$

L – Learning material; M – Media; P – psychological structure; S – Social structure; Z – Setting learning goals

[1] Connectionism models mental phenomena and consequential behaviour with the help of interconnected networks of simpler units.

Accordingly, *B* must be subject to supervised and guided logical cybernetic modelling (Fig. 1). Therefore, within an education system, as plausible teaching-learning process *B* is proposed:

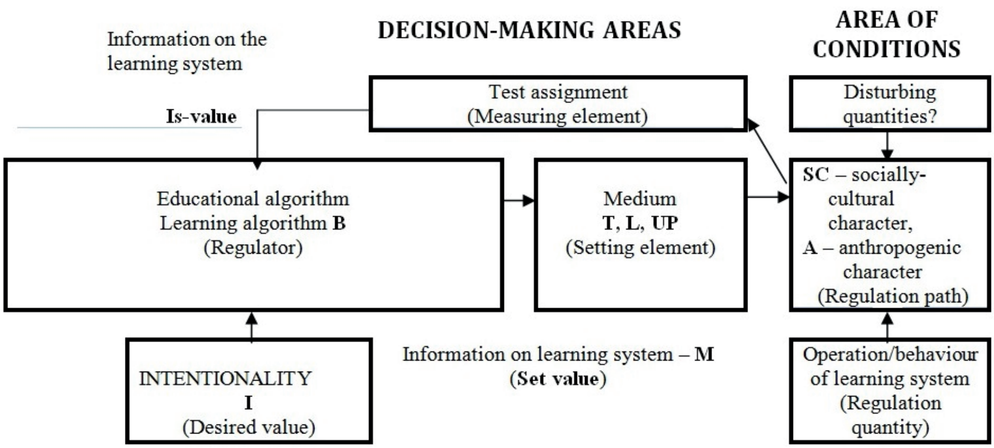

Fig. 1. *Elements and functions in a teaching-learning process applied to cybernetic pedagogy accordingly Frank and Mader (1971)*

It can also be (technically) realised as a learning programme (*intelligent tutor*) (Frank, Mader, 1971; Frank, 1999) if so, it has to include *B* as above formally written in *symbol form*. From a cybernetics standpoint, the teacher and students, learning process and the organisation of lessons become an unique subsystem of an education system.

Problem of Research

When a teaching-learning process *B* was first developed and its authors attempted to realise it in practice, cybernetic pedagogy must have been considered a breath of fresh air in the standard didactic thinking. On our side, we re-define (1) into new (modeling) teaching-learning process algorithm *mRKP* as expressed by a plausible mathematical composition function[2]:

[2] Like in mathematics, in computer science as well, a function composition represents a procedure to combine *simple functions* to build more complicated ones. Since in mathematics a function composition is the pointwise application of one function to another to produce a third function (i.e: $f: X \rightarrow Y$ and $g: Y \rightarrow Z$), then *BmRKP* , as a function composition, still to be a function, but non–generalized because limited to values of *F(T)* and *F(SK, A)*.

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$$B_{mRKP} = f_1\left(I, T, L, f_2\left(T\right), UP, ME, f_3\left(SK, A\right)\right) \quad (2)$$

I – *Intentionality*[3]; T – Topic; L – learning material[4]; UP – Learning aids; M – Didactics / methodology[5];

SK – Socially-cultural character; A – Anthropogenic character

Particularly, with respect (1) and its application (Fig. 1) two more functional dependency included in (2) are remarked:

$$f_1 = \textit{decision-making areas} \quad (3)$$

$$f_3 = \textit{area of conditions} \quad (4)$$

The (2) written of seven conditional variables only is:

$$B_{mRKP} = f_1\left(I, T, L, \psi, UP, ME, \xi\right) \quad (5)$$

Where $\psi = f_2\left(T\right)$ and $\xi = f_3\left(SK, A\right)$.

Despite typical educational problems listed below (A, B, C) – and based on (2) – corresponding solutions (A_s, B_s, C_s) are proposed in the following:

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[3] Its definition is complex since the goals are essentially connected with the topic. A reference point for regulating intentionality can be found in anthropology. Since human behaviour does not exist on its own, but is always a consequence of thinking and emotions, P. Heimann (1976) defines *thinking, wanting and feeling* (head, heart and hands) or, according to B. S. Bloom (1956) *cognition, affection* and *psychomotor skills* as the three *fundamental dimensions of human behaviour*. What is of particular importance is their combined operation, which has to be in tune.

[4] It should be seen in a slightly wider sense than in standard cybernetic didactics and is mainly dependent on the topic and closely related to learning aids.

[5] Lectures in the strict sense.

A. It paid too much attention to how a learning process could be formalised or objectivised as an educational algorithm and expressed as a mathematical logical function with which the learning process could be influenced (optimisation of the learning process) and did not pay enough attention to the learning process itself.	A_s – *solution:* In B_{mRKP} the answers to the question of what a learning process should be like, which are neglected by cybernetic pedagogy, have been found in the *didactics of learning theory* (Heimann, 1976; Jank, Meyer, 2002; Reich, Thomas, 1976; Straka, Macke, 2006), which places the "structural analysis of lessons" at its centre; with this we enrich cybernetic pedagogy, and reject the criticisms if need be. Heimann came up with a surprisingly simple idea of how to set the "basic framework" of a lesson. In order to do so, a particular learning process must be observed closely enough to be able to extract the "*formal constants*" from different types of lessons. Thus established constants can become the guiding constants in analysing as well as planning the lessons (Heimann, 1976). The didactics of learning theory has at its centre a relatively simple structured network made up of six phenomena which categorises those phenomena and places them in the whole via a system of symbols that enable a comprehensive inclusion of all the essential circumstances and decisive tasks of the lesson.

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B. It disregarded the differences between the distinctive psychological and pedagogical features of mental operation on one side and the characteristics of technical systems on the other. Subjugating anthropological characteristics to technical models with the reasoning that the same kind of organisation and laws apply to human thinking as they do for the world of machines is a concept otherwise also known in *structuralism* (Searle, 1983a; Searle, 1983b). Even though the belief that by using cybernetic methods, based exclusively on symbol systems, higher mental activities and processes can also be formalised, modelled and automatically supervised is not uncommon (Frank, Mader, 1971; Cube, 1982), not enough attention is paid to the distinctive features of the educational field in which the student is not only the object of teaching but also the subject of its own control and modification; this is also true when not only one "ideal" student but several students who differ in their cognitive abilities, and thus require different methodology and didactic approaches, are included in the process (Jank, Meyer, 2002). What is striking are the differences between the objectives of human learning and cybernetic learning paths, i.e. between the demand for developing higher, independent mental activities and strictly supervised learning, between generalised, synthetic thinking and particular analytic learning processes, between creativity, differentiation, individualisation and automated learning.	B_s–*solution:* In structuralism it is common belief that the same organisation and laws apply to human thinking as for the world of machines. If we wish to overcome this belief (criticism) and take into account that in modelling of higher cognitive processes the distinctive features of the educational field, where the student is not only the object of teaching but also the subject of its own control and change, structuralism must be replaced with modern *cognitive science* with dynamical systems as the fundamental premise as it has been done in our *mRKP* (Winograd, Flores, 1986; Bermudez, 2010; Markič, 2010).

C. In programming the learning process according to its principles there were particular limitations due to the level of technological progress at the time (Frank, Mader, 1971; Winograd, Flores, 1986); therefore, there was not enough available and capable hardware and software.	C_s–*solution:* The programming learning process was based exclusively on the symbolic notation of the teaching algorithm and thus faced insurmountable barriers (Skinner, 2005). By replacing structuralism with cognitive science we can remove this criticism (Anderson, 2007). The latter supports symbols as well as network systems – this is key to programming a learning process which only works if the formalisation is partially a symbol formalisation and partially a network formalisation. The connectionist models, which draw on the brain's characteristics and their physiological and functional structure, vary from the standard symbol models in certain essential characteristics, such as parallel data processing, content associative memory and divided presentations (Morris, Filenz, 2003).

A question come out: *what does this mean for the formalisation of classes from the viewpoint of the third criticism and for reviving cybernetic pedagogy?*

With respect up cited function composition and related functions (2), (3) and (4), in the following, we try to give some answers:

f_1 – *Decision-making areas:* It is relatively simple to formalise the methodology, topic and learning aids or write them in symbol form with a limited number of modifications of individual factors since the number of methods for achieving the set goals is limited, as is the number of teaching aids and topics. The only problem we are faced with is *intentionality*, particularly as regards learning, since a network system instead of a symbol model would have to be used for its formalisation.

f_2 – *Area of conditions*: Here we are faced with a completely open system of anthropogenic and socially-cultural characteristics that are usually entirely individualised: the former are completely connected to a human being as an individual, whereas the latter are connected to certain groups and communities on the basis of their social and cultural relations. Since we are no longer talking about a specific process with clearly defined goals and limited quantities of content, method and teaching aids related to them, we must use a network system for their formalisation.

It follows that we cannot use the same tools and the same work methods for the symbolisation of both areas (except for intentionality). Symbol systems can be used for

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modelling decision-making areas, as was done in the past, while the area of conditions must be modelled using network systems that enable complex individualisation and differentiation of the learning process.

Finally, cybernetic pedagogy should be treated and presented as a *hybrid system* (as our *mRKP*) since it nowadays combines two different methods (functions) of formalisation supplied by the cognitive platform, symbol and connectionist ones, and not as a symbol system as it was treated and presented in the past.

Research Focus

Nowadays, one of the main methodology problems of electronic learning material – as intelligent tutoring systems (ITS) is their inability to adapt to user‘s demands, needs and, most importantly, their abilities and previous knowledge. E-learning material often has the same scenario, content and goals for all users, regardless of their different abilities and level of knowledge. In other words, all current e-learning material is missing differentiation and individualisation of the learning process from which it is composed (Gur-Zéev, 2005; Aberšek, Kordigel Aberšek, 2011). An answer as to how to avoid this problem can be found in the presented revised cybernetic pedagogy and the use of *mRKP* algorithm. Thus, from the didactic point of view, electronic e-learning material should be designed in a way that would enable the student to learn effectively and independently without the direct presence of a teacher; in this way it would come closest to learning with a teacher and would ensure that the student obtains new knowledge in a permanent and high-quality manner (Bregant, Aberšek, 2011). With certain simplifications, the presented *mRKP* model of the revised cybernetic pedagogy could meet this demand immediately and could also be very easily implemented in the current school practice which will be shown in the case study below.

Intelligent Tutoring Systems: a Case Study

Based on the didactical guidelines of programmed instruction, cybernetic didactic and *mRKP* for the greatest possible individualisation a first part of ITS.

The content of ITS is modularly built from smaller content pieces *building blocks* (Intelligent agents). *Building blocks* are basic and essential elements that affect the quality of ITS. They consist of various learning steps and at the end, they (must) have a summative assessment (Dolenc, Aberšek, 2012). The Figure 2 (on the left) presents such a modular structure of ITS (*learning whole)* composed from different *building blocks* and figure 2 (on the right) presents a structure of one building block. For the presented case study building block *Gear*s was built for the course of Science and technology for the 8th grade of primary school. Such a building block is just a small part of ITS and complies with proposed hierarchical structure (Figs. 2–3) of programmed instruction for such ITS (learning whole).

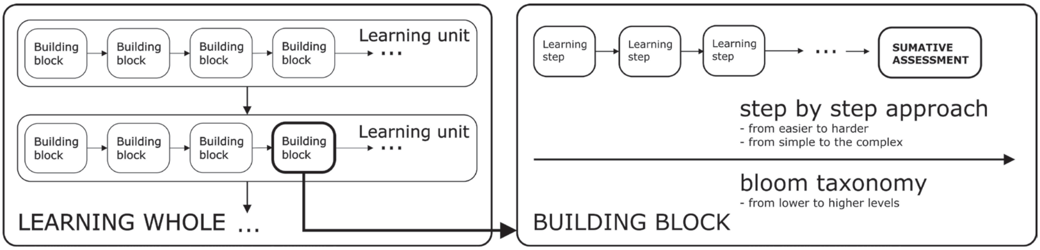

Fig. 2. *Modular structure diagram of intelligent tutoring system*

Building block "Gears" is created in such a way that it provides feedback to students (it guides them through the material), to teachers and creators of the material about students' success at assimilating knowledge and other vital data; metadata. On the bases of metadata, analysis and evaluation of students' educational achievements and the evaluation and optimisation of the individualized e-learning material can be executed (Fig. 4). The smallest piece of ITS is a learning step. Learning steps (Fig. 3) have an appropriated branched structure and are not fragmented but connected to the previous and the following learning steps. They are also adapted to individual needs, levels of knowledge and abilities of students. Each learning step includes regular assessments with feedback that guides students from the beginning to the end. A formative assessment at the end is a part of each learning step.

Learning block *"Gears"* consists from X learning steps, one of them, learning step *axels and shafts* is schematically represented in figure 3.

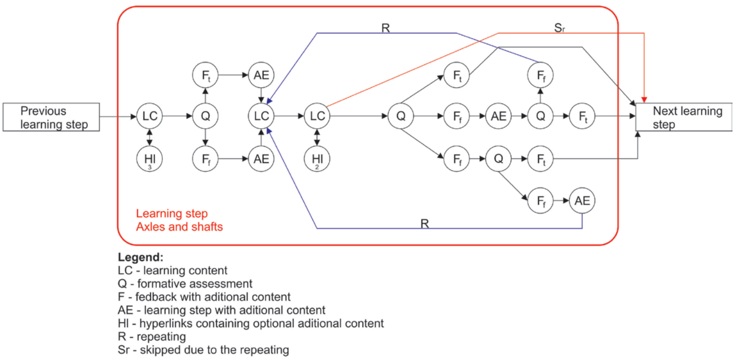

Fig. 3. *Flow chart of an individualized (for axles and shafts) learning step*

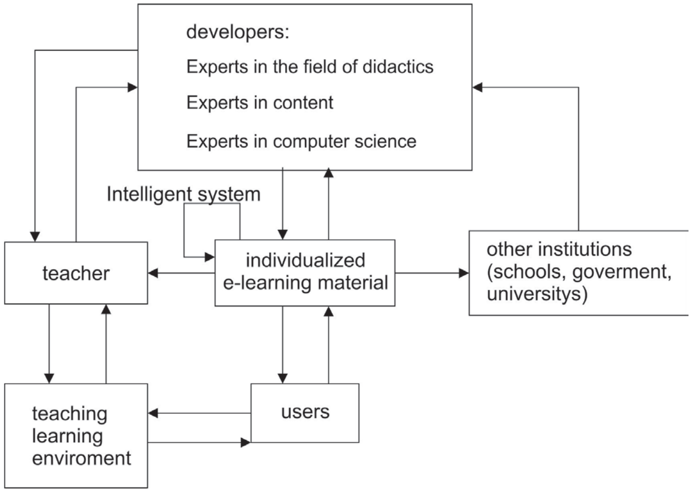

Fig. 4. *Use of metadata obtained in individualized e-learning material*

Methodology of Research

General Background of Research. The object of research is development and evaluation of a pilot model of an individualised ITS for elementary school, in a subject course Science and Technology in the 8th grade. Within the research, different metadata and variables are being collected. The prime topics of interest were:

- ✓ The deviation between levels of knowledge in the individualized ITS (students self-learning) and traditional teaching and
- ✓ How the acquired metadata can be used for improving materials, increasing knowledge of the individuals and analysing and evaluating materials.

Sample of Research. The pilot study is being carried out on a population of 101 students. A traditional teaching model (53 students), with a teacher in the classroom is being directly compared to teaching with an individualized ITS (48 students), without the help of a teacher in the classroom (self-teaching).

Instrument and Procedures. The part (building block "Gears") of individualized ITS was tested in the 8th grade in five randomly chosen elementary schools (suburban and urban). The assessment and testing was carried out in two groups, a control group and an experimental group. While testing, the control group used a traditional approach to cover the subject matter "Gears" during lessons. After the subject matter was covered the acquired knowledge in the control group was assessed in the form of a written test with the help of special research developed questionnaires. On the other hand the experimental group covered the subject matter "Gears" with the help of a pilot ITS. Because of the controlled learning environment the experimental group was introduced to the pilot ITS in school. The teacher was there only as a spectator. The acquired knowledge of the experimental group was assessed in the same way as with the control group, only that the assessment in the experimental group was carried out in electronic form. The summative assessment consisted of 12 exercises, where it was possible to achieve 51 points altogether. Summative assessment according to Bloom's taxonomy included:

- ✓ 7 exercises of a lover cognitive type (knowledge, comprehension, application),
- ✓ 5 exercises of a higher cognitive type (analysis, synthesis, evaluate).

Data Analysis. Quantitative data was collected via summative assessment developed for ITS. Summative assessment of control and experimental group was collected, revised and rated by previously assigned grading. For processing data from both groups we used descriptive statistics for calculating frequency, means and standard deviation.

Results of Research

It is obvious that the students' experience and the quality of their knowledge are most important. From this point of view, in recent years we have talked a lot about efficiency of teaching and the learning process. We all know that two diametrical possibilities exist in these processes, namely "classical" class teaching in large groups (with low efficiency) and individual teaching, 1:1 teaching or one teacher for one student (for example: Socrates and Plato, Plato and Aristotle, Aristotle and Alexander the Great etc.) Average efficiency, if normal (Gaussian) distribution is assumed, according to figure 5 oscillates between 50 % for traditional teaching in the class and 98 % for individual teaching. These are our limits (Aberšek, 2013).

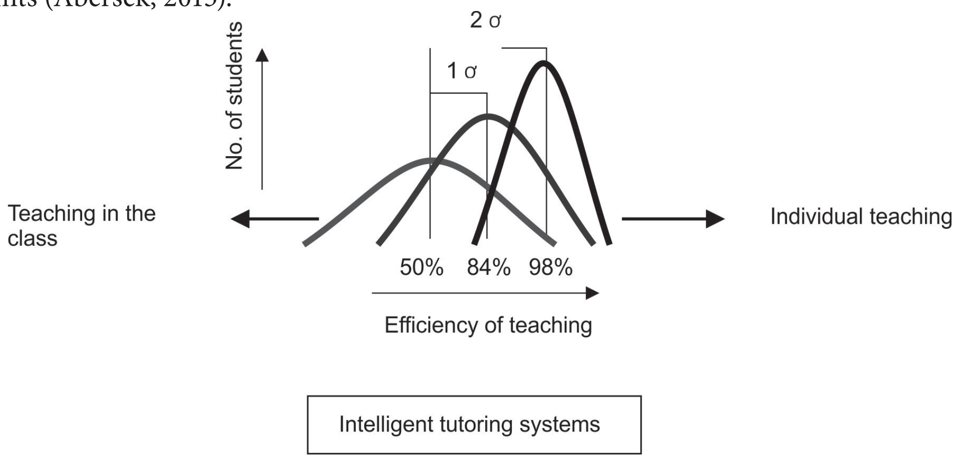

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Fig. 5. *Statistical average efficiency of teaching process*

The results in the control group are in line with average efficiency for teaching (according to figure 5). Results obtained in the experimental group shown in figure 6 show progress in comparison to classic teaching. Nevertheless, they are still behind the suggested 84 % and are oscillating around 60 %.

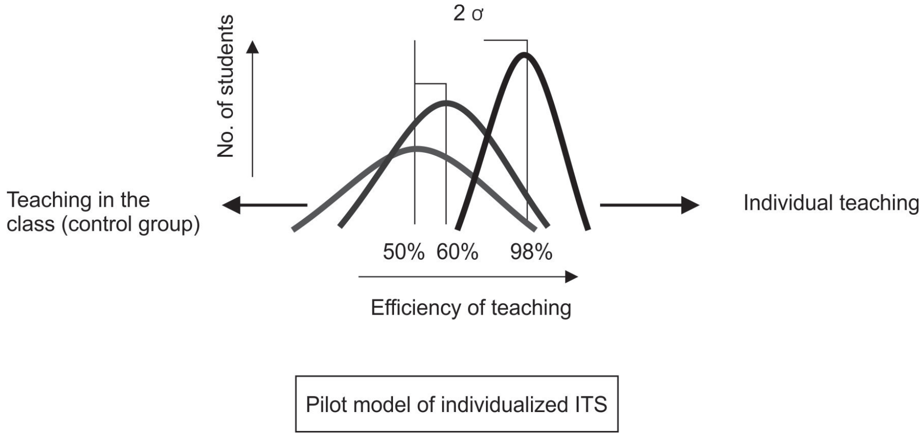

Fig. 6. *Efficiency of pilot model of individualized ITS*

Discussion

Although the data evaluation is still in progress it will be possible, with the help of the metadata collected, to adequately adjust certain contents and didactic pathways of the individualised ITS. Collected metadata will benefit mostly all types of experts who develop such individualised ITS and who could on their bases adequately prepare all further sets. With an appropriate analysis and evaluation of the collected metadata it will be possible to establish which part of the individualised ITS have the student solved normally, without major complications and with which they struggled.

From comparing the ideal results from Fig. 5 to actual results obtained in the research from Figure 6 it is clear that we achieved progress with our ITS but not in the way we expected. The foremost advantage of our ITS is that it is explanatory. In short, from the results (gathered metadata) we can pinpoint the difficulties and thus provide solutions. Because the first step in this process is optimization, the 10 % increase shows a positive trend and confirms that right methods were chosen. In the following steps we will definitely be able to improve the presented ITS. Still a question arise: *has ITS solved the logic and language problematic?*

By considering its paradox aspect as above mentioned, finally, two general ways to present the organization of a scientific theory (Popper, 1959; Popper, 1963) can be claimed: (1) a former one, *Axiomatic Organization* (AO) with a tradition that dating back to Aristotle's arguing, organized through axioms and its logic is classical, (2) a *Problematic Organization* (PO); where a result follows problems *a priori* proposed (Lakoff, Nunez, 2000; Pisano, Gaudiello, 2009; Pisano, 2010; Pisano, Gaudiello, 2010). Accordingly with science education (Osborne, Collins, 2001; Osborne, Collins, 2003) essentially it means *setting and solving problems*; particularly teaching means re–evaluating the relationship between modelling, as well as, theory and experience in – between history and foundations. International debate should take into account pedagogical research on foundations for history and learning–teaching science, discovering science teaching and informal learning activities as well: i.e., to show the real breakthrough of scientific discoveries through the study of the history of foundations.

> The loss of truth, the constantly increasing complexity of mathematics and science, and the uncertainty about which approach to mathematics is secure have caused most mathematicians [and scientists] to abandon science. With the "plague on all your horses" they have retreated to specialties in areas of mathematics [and physics] where the methods of proof seem to be safe. They also find problems concocted by humans more appealing and manageable than those posed by nature. The crises and conflicts over what sound mathematics is have discouraged the application of mathematical methodology to many areas of our culture such as philosophy, political science, ethics, and aesthetics. The hope of finding objective, infallible laws and standards has faded. The Age of Reason is gone. With the loss of truth, man lost his intellectual center, his frame of reference, the established authority for all thought. The "pride of human reason" suffered a fall which brought down with it the house of truth. The lesson of history is that our firmest convictions are not to be asserted dogmatically; in fact they should be most suspect; they mark not our conquest but our limitations and our bounds (Klein, 1980, p. 7, 99).

Conclusion

Information-communication technology (ICT) is already an integral part of all school systems, while e-education and e-material are notions without which we cannot imagine education today. This is why it is even more important that electronic learning material is prepared in a high-quality manner and is intended for active education without the direct presence of a teacher or with their "limited" help, and is not an end in itself, as is often the case today.

We should not be satisfied with copied content from student books and added multimedia and interactive elements since this can cause more damage than benefit. Although such preparation of e-learning material is quick, simple and cheap, it is not necessarily didactic. Electronic learning material is didactical when it enables an individual to achieve the desired goal by stepping onto a path that ensures gradual progression and one's own, personal pace; in short, when it suits the individual. The preparation of electronic learning material demands differentiation and individualisation of individual participants and continuous evaluation not intended as an assessment, but with the purpose of leading the individuals towards the goal on the path that is most suitable for them.

Modern research in education processes shows that the highest educational goals cannot be achieved without active participation by the student. In order to follow the appropriate development of the student's potential it is therefore of utmost importance that we continuously follow and evaluate the educational process, and implement the necessary corrections when needed. This way of working is to a great extent enabled by modern electronic learning material (ITS), but only if it is correctly designed (from the viewpoint of pedagogy and didactics) and technologically implemented. Such material must also, among other aspects, evaluate the user and upon poor results change the path to achieve the planned goals. With cleverly set goals not only can the participants obtain the prescribed knowledge suitable for their level, but we can also enable continuous adaptation of the path towards those goals. We believe that ITS designed on the basis of the revised cybernetic pedagogy and hybrid *mRKP* algorithm can lead to the fulfilment of all of these requirements while they not only symbolise the learning process, but also the social environment in which it takes place.

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Kibernetinės pedagogikos, kognityvinių mokslų ir kalbos sąryšiai

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Santrauka

Straipsnyje nagrinėjamas klausimas, ar įmanoma pakeisti realų mokytoją virtualiuoju (mašina), ir aptariama šio proceso esmė atsižvelgiant į šiuolaikinių technologijų galimybes. Aprašius mokymosi procesą matematinio modelio forma, atsiranda prielaidos sukurti *virtualų mokytoją* ar protingojo e. mokymosi medžiagą. Atspirties taškas natūralistiniam požiūriui į virtualaus mokytojo kūrimo galimybes yra moderni mąstymo filosofija ir kognityvinis mokslas, kurie, moksliniu požiūriu, priklauso skirtingiems pasaulio organizacijos lygmenims. Šiame straipsnyje sutelksime dėmesį tik į socialinių grupių lygmenis, atsižvelgiant tik į tarpasmeninius santykius, santykius tarp mokytojų ir jų mokinių, taigi ir jų elgesį ugdymo procese.

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Mes esame pajėgūs modeliuoti mūsų socialinę sistemą kaip visumą ir aprašyti ją pasitelkus įvairias simbolių sistemas. Tačiau tai tampa daug sudėtingiau ar net neįmanoma, kai mes bandome padaryti tą patį su mūsų *vidine (žmogaus) aplinka*, susijusia su individo *sąmonę*. Siekdami šio tikslo mes stengiamės įsivaizduoti kiekvieną individą, mūsų atveju mokytoją ir mokinį, kaip *reguliuojamą sistemą*, valdomą išorinės kontrolės mechanizmo, kuris nustato skirtingas reikšmes (socialines normas) mokytojų ir mokinių elgesiui per švietimo sistemą. Galima teigti, kad švietimo sistema kibernetinės teorijos požiūriu yra kibernetinė sistema, kuri gali būti formalizuota. Taigi socialinių mokslų srityje kibernetika tampa svarbiu įrankiu siekiant suprasti gyvus organizmus, nes ji analizuoja jų organizacijos lygmenis ir dinamišką ryšį tarp jų.

Remdamiesi fundamentiniais kibernetikos atradimais, straipsnyje mes ieškosime panašumų tarp natūralaus ir dirbtinio intelekto, akcentuodami konektyvistinį požiūrį į „mąstančių mašinų" kūrimą. Vienas iš virtualaus mokytojo (kompiuterinės sistemos) pagrindinių pranašumų yra tai, kad jis gali parengti specialiai pritaikytą mokymo programą (mokymo sistema) kiekvienam studentui, remiantis teisingu individualių pasiekimų vertinimu – ir tokiu būdu veikia panašiai kaip realus mokytojas.

Atskaitos tašku pasirinkta praeito šimtmečio 7-ajame dešimtmetyje kurtos kibernetinės pedagogikos ir didaktikos atradimai, kurių praktinis pritaikymas tuo metu buvo ribotas dėl nepakankamų technologinių galimybių. Straipsnyje pateikiama modifikuota versija modelių, kurie apima specialios rūšies mišrųjį modelį (*mRKP*), kuris galėtų ar net turėtų būti vertinamas kaip esminis visos modernios elektroninės mokymosi medžiagos elementas.

Esminiai žodžiai: *mokymosi procesas, kibernetinė pedagogiką, kognityvinis mokslas, simbolių modeliai, konektyvizmas, mišrios sistemos, programuotas mokymasis, mokymosi algoritmas, e. mokymosi medžiaga, logika ir kalba, mokslas ir visuomenė.*

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