CONCEPTUAL CYBERNETIC MODEL OF TEACHING AND LEARNING

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Abstract: *The article describes conceptual models of learning and teaching as a managed cybernetic system to achieve the knowledge and skills required by the standards. In the article, the learning process is examined as a system for building a knowledge system of a learner actively which is managed and directed by the tutor or teacher to achieve specified learning goal. The information received by the learner has a multimedia nature. The recipient receives the information through various channels (sensors), sight, hearing, smell, taste and touch. The received information arrives in the short-term memory where it is processed - confronted with the previous knowledge in long-term memory of the individual. New information and knowledge can reinforce and extend the recipient's long-term knowledge system if they are consistent logically. If there is a conflict between new information and old knowledge and information - the conflict needs to be solved. The solution can be the clarification of the knowledge system, correction of misconceptions so they are in line with objective reality and relevant knowledge about the subject of learning. It means, learning is not a constant storage of isolated information and information units in memory, but their transformation into active knowledge which is connected to logical structures and forms the knowledge system of the learner. The actual knowledge system enables an individual to solve non-standard problems not only in everyday life but also in science and technology and in various research areas from which the necessary, suitable and useable knowledge (expert) system is built.*

Keywords: MODEL OF LEARNING, MODEL OF MULTIMEDIA LEARNING, CYBERNETIC MODEL OF LEARNING, COGNITIVE PEDAGOGICAL AND PSYCHOLOGICAL MODEL OF LEARNING

1. Introduction

Based on the theory of cognitive learning, learning is a complex process of acquiring knowledge and improving the cognitive abilities of a person. The aim of general education is the wisdom – so the learner becomes a wise man to be able to successfully integrate into other people's society, to share the achievements, material and spiritual values of human society, and to be able to contribute to their development, preserve and transfer them.

The success of human society consists of the fact that it can effectively transfer its knowledge to other generations which are able to further develop it. The continuity in the learning of humanity is ensured by education. A wise society creates a stimulating environment for individuals to learn and to ensure their future development. It creates an access to information sources, provides help, motivation and positive patterns. Education is a lifetime process and it can take various forms. It can be organized and institutionalized which means to take place in specially designed institution (e.g. school) or to take place outside the educational institution during everyday life consciously or unconsciously. The institution confirms formal education obtained at a school with a certificate of education. Knowledge, skills and other personal qualities, which society considers to be significant, are informal evidence of the education of an individual. A person, who wants to use the achievements of human society, must be aware of them. Therefore, the acquisition of knowledge is one of the main aims of education. It is obvious that the knowledge of the individual cannot contain everything. A person chooses what he/she wants and needs to learn. His/her choices are influenced by affects, surroundings and life situations in which he/she is involved.

It is necessary to realize that the knowledge is not transferred to a student, but it is created by thinking. Each information and knowledge acquired by a learner must be transformed into a knowledge by the learner – incorporating them into the learner's own knowledge system. In order for education to be successful, the cognitive abilities and thinking of the learners must be developed by the teachers. It depends on the learners to what depth and quality the knowledge will be achieved, in what way an individual will be able to use it in his/her life, and whether he/she will be able to contribute to its creative development.

Teaching in the school environment will be considered as a controlled learning that aims to achieve the prescribed standard of knowledge. Each individual builds his/her knowledge system for his/her whole life. The knowledge system of an individual is not an encyclopaedia of isolated information units, but a system of knowledge linked to relations expressing the context into one organic whole. In school education, there is a selection of knowledge that a student should master, contained in a curriculum which is created by experts in education in each country. The role of a school is to create a stimulating environment in which the student is motivated to accept this selection of knowledge [14]. School education is the most effective form of education since it focuses on fulfilling the prescribed standards.

2. The Cybernetic Model of Education

It is possible to present the model of the educational system using a control system where the real system is the learner himself, in fact his knowledge system. The process which we manage is student's learning, that means building of the knowledge system of the learner who is supposed to achieve standards in each of the parameters or the prescribed level of the profile of the graduate.

The motivation, the work of the teacher, the acquisition and processing of information (a process of learning) changes the real object. The ideal system which is compared to the real system is expressed by the standards. In case that the learner does not reach the prescribed level of knowledge, based on the difference in knowledge, it is necessary to apply the feedback regulator represented by the teacher, by the influence of the environment and the surroundings, by acquiring new knowledge from different sources, that means learner's process of learning. The feedback regulator does not respond to the positive difference, the situation when the learner knows more than it is prescribed by the standards. However, this may have a positive effect on the activities of the learner and may increase the motivation to self-study [13], [14].

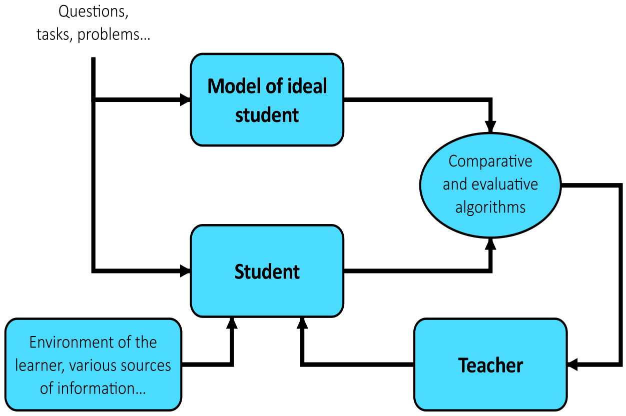

Fig. 1 *Cybernetic model of school education*

3. The model of multimedia teaching and learning

Learner perceives information and knowledge by several senses. Information is mostly gathered by ***sight - eyesight***. According to Fredmann, almost 83% of information we sense with eyesight. Even our research, as well as other researches approved this hypothesis. Graphical information in form of a picture, an animation, a graph etc. can be considered as concentrated form of presenting particular knowledge. Hearing is second mostly used sense for gathering information with 11%. Other senses, such as touch or taste are not as important as sight and hearing. Researches show that we are able to remember only 20% of what we have heard or read, 30% of what we have seen. We are able to remember almost 70% of all information by integration of previous activities with feedback. To be able to remember 80% and more information it is necessary to effectively use gathered information and transfer it into personal system of knowledge. This will help with deduction of new knowledge [03], [04], [16].

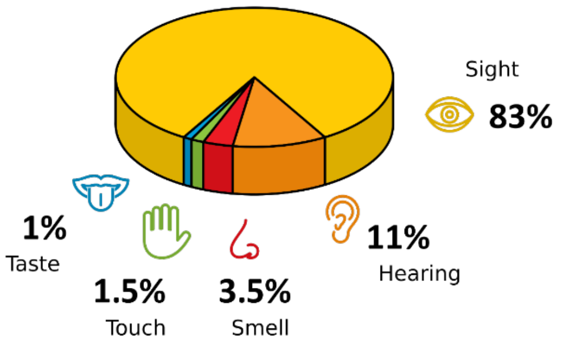

Fig. 2 *How do we get information and knowledge*

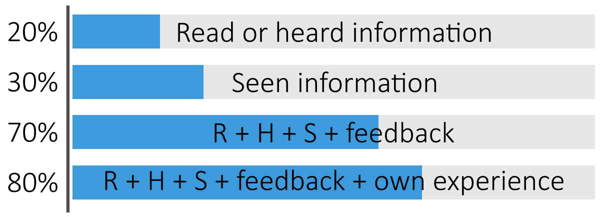

Fig. 3 *How much we remember from the acquired knowledge*

This theory and experimental results are in accordance with Niemierk's and Bloom's taxonomies of educational goals [09], [13].

General taxonomy of cognitive objectives describes 7 levels of how to handle a topic - gathering knowledge. 1 Knowledge, 2. Comprehension, 3. Application, 4. Analysis, 5. Synthesis, 6. Evaluation, 7. Imagination.

Niemierko's taxonomy of cognitive educational goals consists of four levels and is used especially for technical and exact sciences. **Level of knowledge:** 1. remembering; 2. understanding. **Level of competences:** 3. Specific transfer - application of acquired knowledge according presented tasks, in standard situations; 4. Non-specific transfer – an application in new and non-specific – real problem situations.

Niemierko's taxonomy of cognitive aims can be transformed into the knowledge requirements of the learner. The learner knows:

1) To list, to reproduce, to repeat, to name;
2) To explain, to describe, to give examples, to say/express with his/her own words;
3) To apply, to calculate, to demonstrate, to quantify;
4) To compare, to judge, to defend, to justify, to draw conclusions, to generalize, etc.

Bloom's Taxonomy (created in 1956) in order to promote higher forms of thinking in education, such as analysing and evaluating concept, process, procedures and principles, rather than just remembering facts (rote learning) [02]. It contains 6 linear consecutive cognitive levels: Evaluation, Synthesis, Analysis, Application, Comprehension and Knowledge. The cognitive domain involves knowledge and the development of intellectual skills. This includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills. This six major categories of cognitive processes, starting from the simplest evaluation to the most complex knowledge (see the Fig. 4) for an in-depth coverage of each category. The categories can be thought of as degrees of difficulties. That is, the first ones must normally be mastered before the next one can take place.

The original Bloom's taxonomy was revised after 45 years [01]. The order of synthesis and evaluation categories was exchanged. The synthesis has been replaced by the "create" category, which is not understood as a rebuilding of individual elements, but includes a creative element along with the evaluation (the usage of critical thinking). The category of comprehension was renamed to understanding. The cognitive dimensions are expressed in the verb form, while the knowledge dimensions are in the form of a noun (substantive). Bloom's Taxonomy is mostly used when designing or modelling educational, training, and learning processes

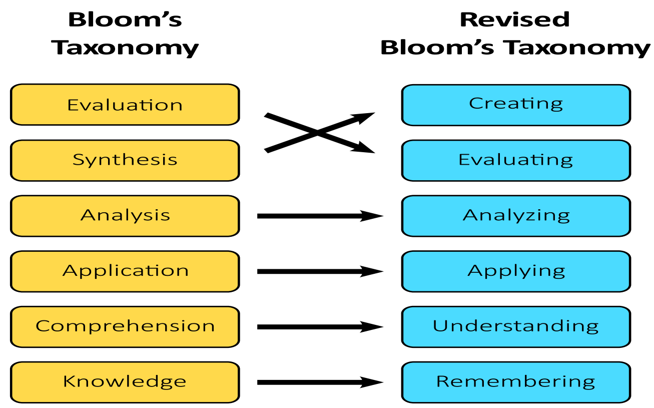

Fig. 4 *Bloom's original and revised taxonomy*

The chart (Fig. 4) compares the original taxonomy with the revised one changing the names in the six categories from noun to verb forms.

Revised Bloom's taxonomy recedes from the hierarchical order of the categories from the lowest to the highest. Overlapping may occur mainly during the educational activities, e.g. the learner sometimes evaluates even though he/she had not analysed the subject matter, or he/she creates new knowledge on the basis of partial knowledge. However, all dimensions should be shown. Table 1 provides examples of possible student activities for each of the component of the knowledge and cognitive dimension. Insertion the objective into the table is not always so easy and unequivocal. The formulation of the educational objectives and their taxonomic classification helps the teacher to choose the teaching methods (methods and forms of teaching) as well as it helps him/her in assessment, which is appropriate to the nature of the objectives [09]. The activity of the teacher and the learner should correspond to the chosen educational objective. Today, Bloom's taxonomy is easily understood and probably the most often applied one.

Table 1: *examples of possible student activities for each of the component of the knowledge and cognitive dimension*

The Knowledge Dimension	*Remembering*	*Understanding*	*Applying*	*Analyzing*	*Evaluating*	*Creating*
Factual Knowledge	List	Summarize	Sort, classify	Order	Choose	Combine
Conceptual Knowledge	Describe	Interpret, recognize	Experiment	Explain, compare	Estimate,determine	Plan, outline
Procedural Knowledge	Organize	Predict	Calculate, solve	Differentiate, depict	Conclude	Compose, design
Meta-Cognitive Knowledge	Appropriate Use	Process	Construct	Create	Perform, express	Actualize,improve

The effectiveness of learning is closely related to the participants' activity. Already, Edgar Dale (1900-1985), an American educational researcher, has found this in conjunction with developing the "Cone of Experiences" [05], which shows the effectiveness of the different teaching methods. From this we can see that the best methods are based on being more reliant on learner activity (Fig. 5). For this reason, today's most popular educational methods are all focused on activities of learners such as Inquiry-Based Learning, Problem-Based learning or Project-Based Learning. At the top of the pyramid are the less-active methods, where we listen and read the learning materials. In order for the educational environment to be effective, action, interaction and creativity should be introduced into education. This methods are located at the bottom of the cone [03], [04], [05], [06], [15].

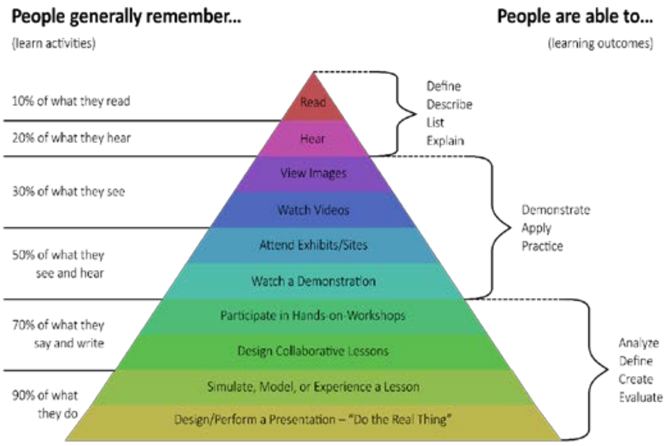

Fig. 5 *Cone of Experiences*

4. The Model of Knowledge System Creation

The teacher in the educational process affects the learner with the intention of achieving educational goals. Teaching is considered to be an optimal way of getting necessary knowledge. In implementing the learning model, it is important to apply both the taxonomy of objectives as well as the effectiveness of the various sources of knowledge and information that are acquired through different channels and the existence of different learning methods and styles. An important part of the learning model is the **presentation of knowledge** and information which are the subject of learning. This subsystem is part of the **model of the (ideal) teacher**. Learning material should be presented with the appropriate pedagogical transformation, in a multimedia structured form, with the respect to the student's mental level and his/her active involvement in the learning process. Another model of the subsystem of the teacher **is the management of the learning process**. It is necessary to identify learners, their learning style, their current level of knowledge, etc. to optimally manage the process of learning in order to individualize the learning process and shorten the time that is necessary to process gained information and knowledge. Incorporating new knowledge into the learning system of the learner means confronting new knowledge with knowledge in one's own knowledge system. In the case that the new knowledge is in accordance with the existing ones, the knowledge is deepened, and its durability is increased [16], [19]. If a conflict arises in assessing and processing new information and knowledge with the old ones, it needs to be solved. Thus, the individual constantly builds and improves their own knowledge system not only by consciously searching for new information and by checking and using it in practice, but also by the influence of the environment where the learner lives and in contact and communication with others. The objective of building the knowledge system is to make the individual wise, to change the quantity into the quality, so that understood (passive) information and knowledge become active, and therefore the individual is convinced of their relevance.

The knowledge system of an individual is not an isolated information and knowledge, but a system of knowledge – knowledge which is interconnected by relations that express the connection between knowledge. The knowledge system contains knowledge that is useful for solving everyday life problems, problems in professional life, employment problems and the problems of society we live in.

The learner analyses the acquired information, confronts them with knowledge of his/her own knowledge system, tests them by active usage, and incorporates them into his/her own knowledge system by synthesis, in other words the new information become knowledge. (See the Fig. 5.) It is according the rule of learning where the ultimate goal is a wise learner. „From information and knowledge to wisdom“.

In the Fig. 5 can be seen how the learner processes information and knowledge that is presented in different forms and how he/she creates his/her own knowledge system.

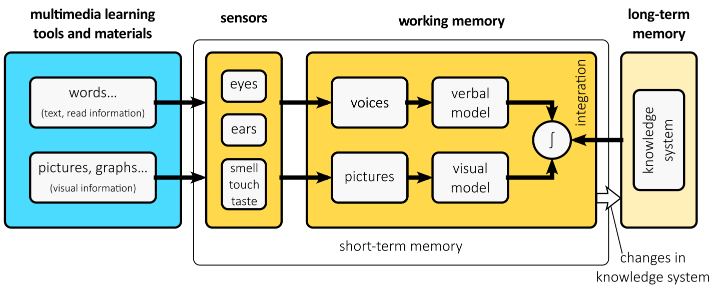

Fig. 6 *Model of knowledge system creation*

5. The Knowledge System Building

In constructing the graphical model of building the knowledge system, we proceeded from the cognitive theory of multimedia learning of Mayer. Mayer, based on his research, developed the Cognitive Theory of Multimedia Learning, based on 12 principles, which should be taken into account when developing multimedia teaching materials. These principles were grouped into three main categories [08].

I. Reducing processing of information not covered (Coherence Principle; Signalling Principle; Redundancy Principle; Spatial Contiguity Principle; Temporal Contiguity Principle).

II. Control the processing of relevant information (Segmenting Principle; Pre-training Principle; Modality Principle).

III. To promote constructive processing of information (Multimedia Principle; Personalization Principle; Voice Principle; Image Principle).

In the Fig. 5 is illustrated how a knowledge system is built and it is also easy to see how the human brain processes several types of information.

On the basis of the results of Mayer's research, the basic principles of multimedia learning have been developed. Those results are confirmed by our research results in the area of the usage of the multimedia learning aids for programming in forms of animation-simulation models, which we have accomplished during the past years at J. Selye University in Komárno as well as at Trnava University in Trnava. The animations were developed in HTML5 using JavaScript technologies. We also used the CreateJS libraries (www.createjs.com) for animating the objects.

Our research results have shown that when the explanation of teaching material is in textual form, it is important to give students enough time to read and comprehend it. According to the principles of Mayer's multimedia learning, it is not recommended to show the text and animate the objects on the screen at the same time. It is better to let students start the animation themselves after reading and understanding the explanation. Another possible solution could be to use narration during the animation instead of textual explanation [16], [17], [18], [19].

The results of several experiments emphasized that the animations may be used more efficiently when they are not displayed alone, but when they are part of a learning environment. This environment could be an electronic textbook with hypertext structure, enriched with embedded animations, diagrams, and examples [19].

The limited scope of the article does not allow detailed analysis of the individual subsystems of the model. We plan to publish this analysis in the next article about the modelling of the learning process.

6. Conclusion

The model of learning – building of the knowledge system of the learner can be implemented in various ways. It might be built as a learning expert system [12], a virtual "second life" university or as a learning environment created with the support of LMS and CMS, where the presentation of knowledge can have a different form, e.g. multimedia interactive animation-simulation model of the studied phenomenon, or dynamic process [10], [11]. The management and optimisation of the learning process should be realised on the basis of the logical hyper-structure of the knowledge of the studied object, which is the subject of the education. In that case the logical hyper-structure of the knowledge contributes to the systematisation of the knowledge and to the correct improvement and building of the knowledge system of the learner. These kinds of education systems must be implemented in a such way that their utilization reduces the time needed to understand new knowledge, to process them and to convert them into active knowledge, that are useful and easily accessible in the long-term memory of the learner. They help him/her solve various problems, not only in the professional field, but also in everyday life. If we want educational software systems, which support learning, to deliver the expected effect, we must respect the rules of creating and building a knowledge system and the pedagogical, psychological and didactic rules of learning.

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