POSSIBILITIES OF COMPUTER VISUALIZATION OF THE SYSTEM OF THE LOGICAL STRUCTURE OF NATURAL SCIENCE CURRICULUM FOR PUPILS OF YOUNGER SCHOOL AGE

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The article discusses the topic of computer visualisation of the educational contents of natural sciences subject taught at primary level, i.e. from the first to the fourth grade of primary school. The need to visualise logical causality in the contents of natural sciences is a result of several years of teaching experience proving that while a pupil might be able to describe facts and processes of natural sciences, it does not necessarily mean he/she understood the mechanism behind these facts and processes. In the minds of pupils the facts are often out of context and causality. Therefore, the solution to the missing causality of the learning contents logical structure could be a computer visualisation of the learning contents. Visualisation is a graphic (visual) representation of a group of key logical areas/terms and their interconnection. The structural components used for primary school pupils are the following: word maps, orientation graphs, structure grams, development/sequence diagrams, Venn diagrams, tables and graphs. The article also presents an innovative system of teaching natural sciences to primary school pupils, which has been proposed and experimentally tested in the practice over several years. The main reason for development of this system was to innovate the existing well-functioning and methodologically detailed traditional system of teaching, rather than replacing it. Our intention was to show new possibilities of the innovation systems extending the boundaries of the traditional ones. Such a symbiosis builds on positive sides of both systems while limiting or completely excluding the negative ones. The final part of the articles presents the results of educational experiment carried out in the last school year. The experiment tested effectiveness of applying computer visualisation to the process of learning/acquisition of the educational contents of the natural sciences in primary school pupils.

Keywords: computer visualization of the system of the logical structure of curriculum, natural science, primary school, pedagogical experiment

The article deals with the issue of computer visualization of the system of the logical structure of natural science curriculum for pupils of younger school age attending primary level of education, i.e. from the 1st to the 4th grade of primary school.

The need to visualize logical causality in the contents of natural sciences is a result of several years of teaching experience proving that while a pupil might be able to describe facts and processes of natural sciences, it does not necessarily mean he/she understood the mechanism behind these facts and processes. In the minds of pupils the facts are often out of context and causality. Therefore, the solution to the missing causality of the learning contents logical structure could be a computer visualization of the learning contents.

Logical structure of the curriculum

Under the visualization of the system of the logical structure of curriculum, we understand a graphic representation (visual presentation) of a set of logical key points in the curriculum and the logical links between them (Bernátová, 2001).

We encounter with the issue of the logical structure of curriculum and its impact on learning in theoretical and experimental level in Bruner (1965) and in application level in Šatalov (1987). In relation to the technological context, the system of the logical structure of curriculum can be visualized in two forms:

a) the traditional graphic form, for example, the drawing on a blackboard, wall painting, compositional slide, the application on a magnetic wall, slides, etc.;
b) the form of a virtual computer-based presentation of the software-type Power Point, Flash and others (Bernátová, 2002).

We will deal with virtual (multimedia) visualization of the logical structure of curriculum and its possible applications in education in details in the following part of the article.

Computer visualization

Dominant context of the application of computer technology (brings specific aspects into the education, which can be also used in the visualization of the system of the logical structure of curriculum) can be summarized as:

- ✓ multimedia, which mainly facilitate the visual and auditory imagination of the phenomenon, which shortens the learning process;
- ✓ the possibility of animation and simulation of processes, which allows to create a model of the behaviour of the real process on the basis of different input values and subsequent animation of results of output, which allows the “deceleration and acceleration” of processes;
- ✓ the interaction between user and computer, which is one of the important features of multimedia.

In relation to the listed aspects of computer image of visualization of the system of the logical structure of curriculum, it allows in contrast to traditional graphic visualization:

a) to visualize the logical links between the elements of curriculum in the various sites;
b) to establish a system of mutually plunged subsystems of the virtually visualized system of the logical structure of curriculum created in the form of integrated modules;
c) to complement the virtually visualized system of the logical structure of curriculum on the audio commentary, i.e. the computer simulation and animation as well as movie;
d) to make the virtually visualized system of logical structure of the curriculum available to the general public with the help of the Internet computer network;
e) to modularly display the logical structure of the system of curriculum in the different rades of school education;
f) to complement the implementation of the visualized system of logical structure of the curriculum on computer simulations, animations and movies;
g) to project the system of the logical structure of curriculum implemented on basis of presentation programs such as PowerPoint on the classic screen (or via an interactive whiteboard), clearly visible for the whole class of pupils;
h) to dynamize the presentation (movement, effects, etc.) of individual images (pages) as well as individual objects of that system of the logical structure of curriculum;
i) easy reproduction, i.e. undemanding spatial archiving of recordings by media carriers of information, makes it possible to create the necessary changes to product (e.g. in connection with the rapid growth of scientific knowledge) (Bernátová, 2002).

Structural components

When visualizing the system of the logical structure of natural science curriculum, we use mainly the following structural components: word maps, orientation graphs, structure grams, development/sequence diagrams, Venn diagrams, tables and graphs (Bernátová, 2001).

Word maps are very suitable for the record of logical links in the hierarchy of the system of concepts in curriculum.

Structure grams form "binder, carrier base, bond or a pillar" between the structures in curriculum. They give to curriculum the "systematic breath", but especially "skeleton" of global structuring of the curriculum (structural elements are not isolated, but form a whole system). They are a simplified variant of the flat block diagram in its graphical nature. In the diagram, every single block is designated generally by rectangular (less circle, triangle, etc.) frame; the lines between the blocks indicate their relationships. The horizontal lines are the signs of equivalence; the vertical lines usually mean inclusiveness. In general, under the structure gram we will understand the link of a set of blocks by the set of orientation lines.

In *the development diagrams*, the record consists of a decision block, in which the condition for branching and orientation of lines (arrows) entering into and exiting from the decision block (branching alternatives) is recorded.

Orientation graphs are particularly useful for the record of the logical structure of curriculum resulting from the transport nature of the phenomenon. Graphic shape is the oriented line (arrow) from the source to the target place of transport. Along the orientation line, there is usually recorded the essence of the transport mechanism (e.g. chemical equation) or transported media.

Venn diagrams are symbolic record of a set and a predicate logic and create a very convenient connection with other types of components.

When visualizing the curriculum for pupils of younger school age, we also use other types of structural components such as graph of function, table, mathematical symbols, graphs of the time sequence, maps and plans, etc.

Visualized system of the logical structure of curriculum as a whole consists of a clear-cut or mixed types of structural components. Their selection and the use depend on the age of pupils, curriculum content as well as aims of the learning process.

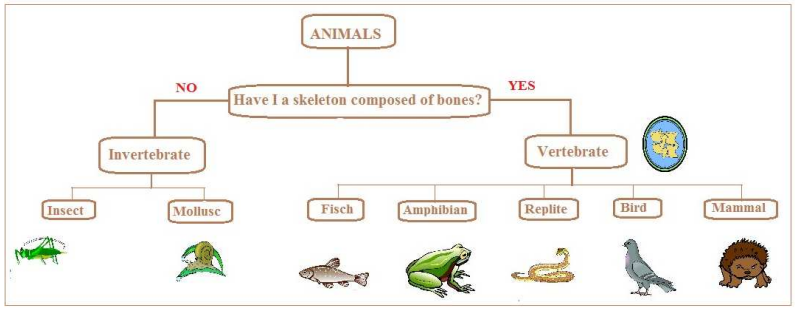
Principal essence of the application of computer visualization

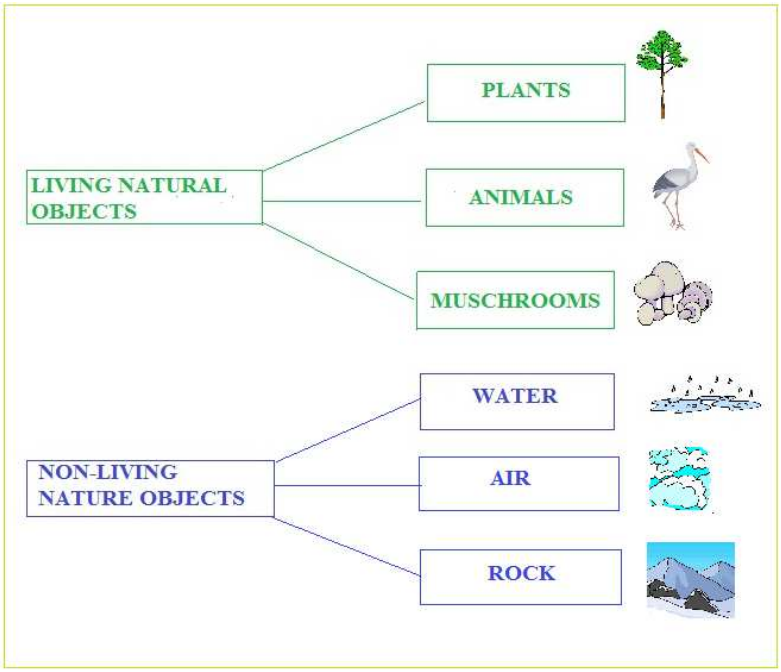
Application of computer visualization of the system of the logical structure of curriculum in education of pupils of younger school age proposed by us is based on the principle that the system of education applying computer visualization of the logical structure of the curriculum should not displace or replace the traditional teaching in any case, but it should complement it in harmony with it in raising clearness especially when repeating and reinforcing natural science curriculum.

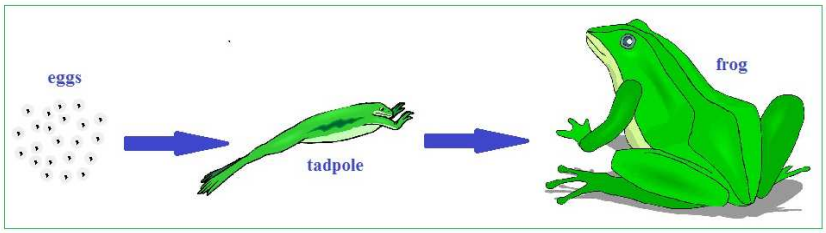
Pedagogical experiment

The aim of pedagogical experiment was to verify the effectiveness of the application of computer visualization of the system of the logical structure of curriculum in the process of acquisition of the natural science curriculum by pupils of younger school age. We chose two groups for pedagogical experiment. Independently variable was the way of the organization of cognitive activity of pupils, with which we manipulated (experimental change), dependently variable was the performance of pupils in the cognitive area. Pedagogical experiment was carried out from January to June 2011 in natural science subjects for the 4th grade of primary school. In the experimental group, there was computer supported learning (using a computer visualization system of the logical structure of curriculum) applied in the natural science lessons and in the control group, there was education carried out without computer support (using traditional way of teaching).

Examples of the computer-visualized system







Research sample

The research sample consisted of 118 pupils of the 4th grade from the five primary schools of the eastern region. Pupils of the 4th grade forming a research sample were on the basis of results achieved in the input didactic tests divided into experimental and control group. 58 pupils were placed in the experimental group and 60 pupils in the control group. The experimental group consisted of elementary school pupils from primary schools of Slanec, Chminianska Nova Ves and Zahradne. The control group consisted of pupils from the primary school of Ľubotice and Ceskoslovenska armada. By the analysis of variance (F - test) at significance level 0.05, we checked the equivalence of the sample - an experimental and control. In Excel, we calculated the test criterion (F) and we compared it with a critical value F_{kr}, which we found in statistical table in the publication Horák and Chráska (1989). We calculated the test criterion F = 1.99037. The critical value at significance level of 0.05 is F_{kr} = 3.92. In our case 1.99037 <3.92, which

means that between the experimental and control group is not statistically significant difference at significance level of 0.05. At the beginning, we considered experimental and control group to be equivalent.

Pedagogical experiment was carried out from January to June 2011. In the experimental group, there was applied the computer supported curriculum of the natural sciences (using the computer visualization of the system of the logical structure of curriculum) and in the control group, there was education carried out without computer support (using traditional way of teaching).

In addition to input and output didactic test, pupils of experimental and control group were even continuously writing tests after completion of curriculum of individual thematic units. In our article, we want to present the achieved results in continuous didactic test from the curriculum of the thematic unit Diversity of nature and its cognition (time span of 5 hours teaching). An educational package, which was created by us, contained four sets of logical pillars and applets. The continuous didactic test was written by 54 pupils of experimental group and 56 pupils of control group. Continuous didactic text was written by pupils in the first week of May.

Characteristics of the continuous didactic test

Continuous didactic test from the curriculum of the thematic unit Diversity of nature and its cognition contained 12 testing tasks. 7 testing tasks were opened – production and complementary, 5 were closed – 4 polytomic a 1 dichotomous.

According to Niemerkova's taxonomy of cognitive aims, we divided testing tasks into two subtests. Subtest A contained 8 testing tasks to memorize knowledge. Subtest B contained 4 testing tasks for comprehension of knowledge. We used a composite score. The maximum score for the test was 14.5 points. We assigned a maximum of 1 point to testing tasks for comprehension and 1.5 points for one testing task. We assigned 2 points to two testing tasks for comprehension and 1 point to two.

Evaluation of the continuous didactic test

The percentage of the successful solutions of the test of the experimental group was 70.05% and of the control group 60.22%. In Excel, we calculated the F criterion; in statistical tables we found the critical value for significance level 0.05. Statistical significance of the difference between experimental and control group achieved in performance in the continuous didactic test as a whole is documented in the following table.

Continuous test as a whole

n = 110	F_{kr} (1,108) = 3,92	F = 11,25446	sign (0,05)

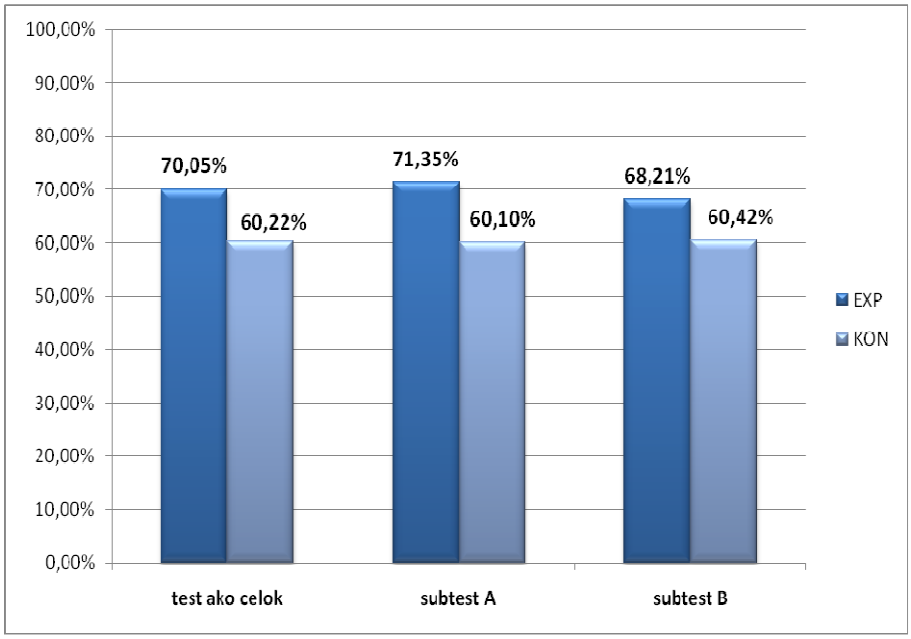
Calculated F was 11.25446. F_{kr} = 3.92. Since F > F_{kr}, we can say that in the pupil's performance achieved in the continuous didactic test is statistically significant difference between experimental and control group at the significance level of 0.05.

Table 1. *Achieved performance of pupils of the 4th grade in the continuous didactic test and its subtests displayed in relative metrics (in percentage)*

	Experimental group – E	**Control group - K**	**E –K**
Subtest A	71,35	60,1	11,25
Subtest B	68,21	60,42	7,79
Test as a whole	70,05	60,22	9,83

The comparison of results showed that the differences in the successful solution of individual subtests between experimental and control group were as follows: 11.25% in memorizing and 7.79% in comprehension in favour of the experimental group (see Table 1). Pupils of experimental group achieved in the continuous didactic test from the natural science for the 4th grade of 70.05% success in solving, pupils of control group of 60.22% (see Graph 1).

Graph 1. *Percentage of successful solution of the continuous didactic test by experimental and control group*



Statistical significance of the difference between experimental and control group in performance of individual subtests of the continuous didactic test is illustrated by the following tables.

Subtest A

n = 110	F_{kr} (1,108) = 3,92	F = 10,85375	sign (0,05)

Calculated F for subtest A was 10, 85375. F_{kr} = 3.92 (at the significance level of 0,05).

Subtest B

n = 110	F_{kr} (1,108) = 3,92	F = 4,238351	sign (0,05)

Calculated F for subtest B was 4, 238351. F_{kr} = 3.92 (at the significance level of 0,05).

In both subtests, the calculated value F was greater than the critical value. Therefore, we can conclude that in the pupils' performance in subtest A and subtest B, there is a statistically significant difference between experimental and control group at the significance level of 0.05.

Conclusion

In conclusion, we would like to say that we present only partial results of the continuous pedagogical experiment in the article, which we implement in the second, third and fourth grade of primary school in the curriculum of natural science subjects. The current results described in our article show that computer-supported learning of natural science subjects (applying computer visualization of the system of the logical structure of curriculum) in the 4th grade of primary school has a positive impact on the acquisition of the educational contents of the natural sciences by primary school pupils.

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