Journal of Science Education Vol.21 n◦ 2 2020

Journal of Science Education

ISSN 0124-5481

Teaching of the Thematic Unit Photosynthesis in the Natural Sciences with Didactics for Teacher Training Programmers in Primary Education with the Support of the Interactive Whiteboard

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ARTICLEINFO

Keywords:

Teaching of the thematic unit photosynthesis

Natural sciences

Interactive whiteboard

ABSTRACT

The interactive whiteboard represents a new modern technology of teaching compared to the classical one. Teaching with an interactive whiteboard may or may not be truly interactive for students (pupils). It depends on its use by teachers. The potential little pedagogical benefit of interactive whiteboards is related to the insufficient didactic and technological competencies of teachers, but it cannot be considered as a generally valid argument for rejecting technology. A classic example is the use of an interactive whiteboard for ordinary projection. Such a method of using expensive technology is of course technically, financially and humanly inefficient. The main didactic attributes of displaying using an interactive whiteboard can be symbolically characterized as follows: Symbiosis = above real visualization + PC interactivity. In terms of concreteness: • the application of computer animation and simulation (the ability of processes and phenomena running in science systems to slow down, accelerate or shred in time, but also to virtualize objects that ca not be seen with the naked eye – they are too small, or large, inaccessible to humans, or real non-existent, etc. • the application interactive components called interactive computer graphics (hypertext, drag and drop, etc.). The paper presents the visualization of biochemical (and biological) objects, processes and phenomena taking place in Photosynthesis in a degree of visualization that cannot be achieved by traditional visualization methods (it is beyond the natural limits of traditional visualization methods). Specifically, it is the application of the mentioned visualization by an interactive whiteboard in the teaching of the subject Natural Science in the university study program – Teacher training programmes in primary education. The research also includes a pedagogical experiment to verify the effectiveness of teaching with the interactive whiteboard applied compared to the traditional way of teaching without an interactive whiteboard.

1. Introduction

The interactive whiteboard represents a new modern technology of teaching compared to the classical one. Teaching with an interactive whiteboard may or may not be truly interactive for pupils. It depends on its use by teachers. The potential little pedagogical benefit of interactive whiteboards is related to the insufficient didactic and technological competencies of teachers, but it cannot be considered as a generally valid argument for rejecting technology. A classic example is the use of an interactive whiteboard for ordinary projection. Such a method of using expensive technology is of course technically, financially and humanly inefficient.

This article describes some of the options offered by interactive whiteboard software. The slideshow contains all of the illustrative elements such as, for example - Pictures, videos and animations, just need an Internet connection and speaker connections to play audio from videos and sound effects. In its proper use, teachers should have in the learning process more effective educational goals. Finally, we can summarize that the interactive table is a modern didactic tool that use be cannot in all the topics that are taught in schools. Certainly, it will contribute to the professional subjects to improve and make more effective the acquisition of students and pupils' knowledge, skills and habits in the teaching process and is a very good means of motivating pupils and students. 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 educational subject Natural sciences with didactics for teacher training programmers in primary education. The current results described in our article show that computer-supported learning of natural science subjects in has a positive impact on the acquisition of the educational contents of the natural sciences by school students. Teachers with proper use should have in the learning process more effective educational goals. We can finally summarize, that the interactive table is a modern didactic tool that

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Accepted 2 June 2020, Available online 1 December 2020

cannot use in all the topics that to teach in schools. It but will certainly contribute to the professional subjects to improve and make more effective the acquisition of students and pupils' knowledge, skills and habits in the teaching process and is a very good means of motivating students and pupils.

Research into innovations in science-oriented subjects, which are published by the authors of this article, can be found, for example, in (Bernátová, 2009, 2018; Bernát, 2005; Bernátová, Bernát, & Cimbala, 2009).

2. The main didactic attributes of displaying using an interactive whiteboard

The main didactic attributes of displaying using an interactive whiteboard	==	Above real visualization	+	PC interactivity

Fig. 1. The main didactic attributes of displaying using an interactive whiteboard

(Note: Symbiosis = above real visualization + PC interactivity)

In terms of concreteness:

- the application of computer animation and simulation (the ability of processes and phenomena running in science systems to slow down, accelerate or shred in time, but also to virtualize objects that ca not be seen with the naked eye – they are too small, or large, inaccessible to humans, or real non-existent, etc.
- the application interactive components called interactive computer graphics (hypertext, drag and drop, etc.).

The paper presents the visualization of biochemical (and biological) objects, processes and phenomena taking place in Photosynthesis in a degree of visualization that cannot be achieved by traditional visualization methods (it is beyond the natural limits of traditional visualization methods). Specifically, it is the application of the mentioned visualization by an interactive whiteboard in the teaching of the subject Natural sciences with didactics for teacher training programmes in primary education. The research also includes a pedagogical experiment to verify the effectiveness of teaching with the interactive whiteboard applied compared to the traditional way of teaching without an interactive whiteboard.

3. Teaching of the thematic unit photosynthesis in the natural sciences with didactics for teacher training programmes in primary education with the support of the interactive whiteboard

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 line (Fig. 1-3).

In our pedagogical practice we use two types of structure grams. Structure grams (based on anatomical nature) and Structure grams (based on physiological nature). The structure diagrams used in the following section belong to physiologically oriented structure programs.

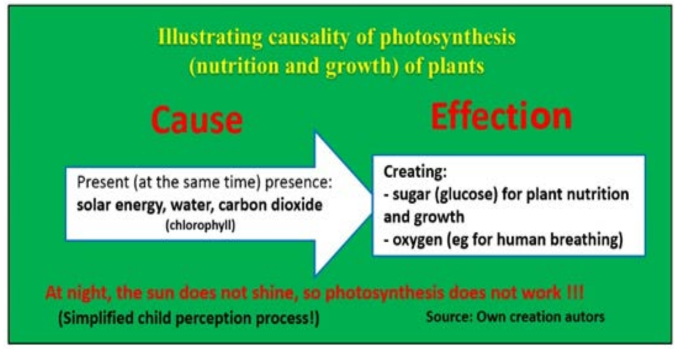

Fig. 1. Structure grams - Illustrating causality of photosynthesis - Cause – Effection (support of the interactive whiteboard).

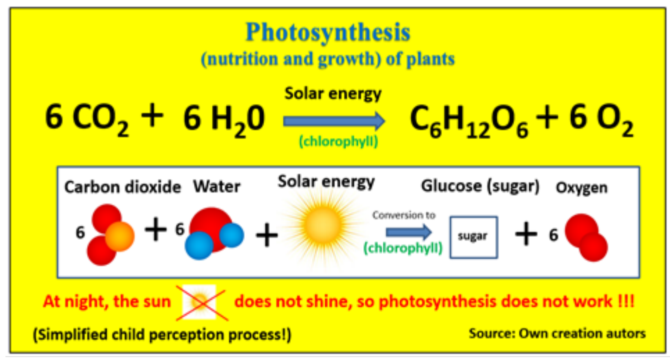

Fig. 2. Structure grams - Photosynthesis - nutrition and growth of plants (support of the interactive whiteboard).

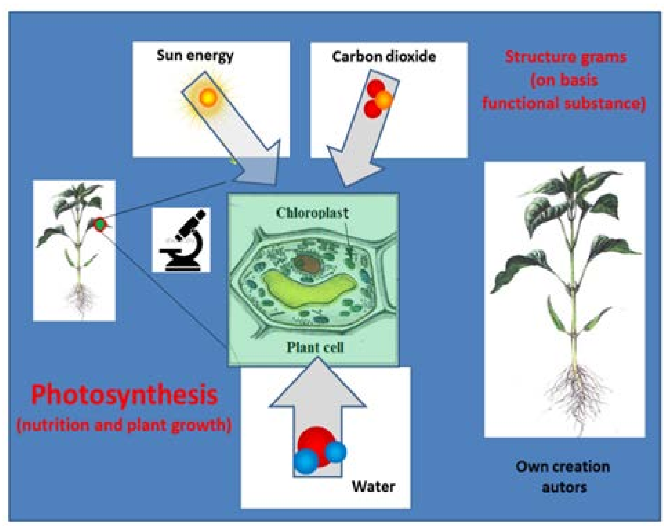

Fig. 3. Key sekvences of Java applet, Structure grams - based on physiological and biochemical nature. (support of the interactive whiteboard) (a).

Fig. 4. Key sekvences of Java applet, Structure grams - based on physiological and biochemical nature. (support of the interactive whiteboard) (b).

Based on the systemic understanding of the biochemical system, which is photosynthesis (and its imaging by the structural program), its didactic application primarily emphasizes the causality of biochemical reactions (causal connection in the context of cause-effect). Last but not least, the specification of inputs and outputs to and from the biochemical system, but also the specificity of the running of biochemical processes of photosynthesis - (photosynthesis during the day and night, photosynthesis in individual seasons, etc.).

Present application of intelligent computer graphics in conjunction with the application of computer animation and simulation (the ability of processes and phenomena running in science systems to slow down, accelerate or shred in time, but also to virtualize objects that ca not be seen with the naked eye - they are too small, or large, inaccessible to humans, or real non-existent, etc. The interactivity of the computer, student, teacher allows application components called interactive computer graphics (hypertext, drag and drop, etc.).

We created structured programs (based on physiological and biochemical nature) called Photosynthesis (Cause - Effection) and the second How photosynthesis works? The aim of the pedagogical experiment, which is described in the part – Methodology of the article, was the method of pedagogical experiment used to compare the two teaching systems in the experimental group and the control group (traditional teaching system).

4. Teaching of the thematic unit photosynthesis in the natural sciences in primary level education with the support of the interactive whiteboard

Applet: To put it simply, the applet is one purpose (especially educational) program, which was developed on the platform of the so-called modern elements intelligent computer graphics (Fig. 5-7). These elements make it possible to visualize of the logical structure of the curriculum only in the degree of clarity that cannot be achieved otherwise (that ca not be attain with traditional technologies and techniques of visualization). In terms of concreteness:

- the application of computer animation and simulation (the ability of processes and phenomena running in science systems to slow down, accelerate or shred in time, but also to virtualize objects that ca not be seen with the naked eye - they are too small, or large, inaccessible to humans, or real non-existent, etc. In particular - highlighting the clarity of the kinetics (speed, sequence and concatenation of the running) of individual biochemical reactions associated with photosynthesis.
- application components called Interactive computer graphics (hypertext, drag and drop, etc.). We created applets called Photosynthesis (Cause - Effection), How photosynthesis works?

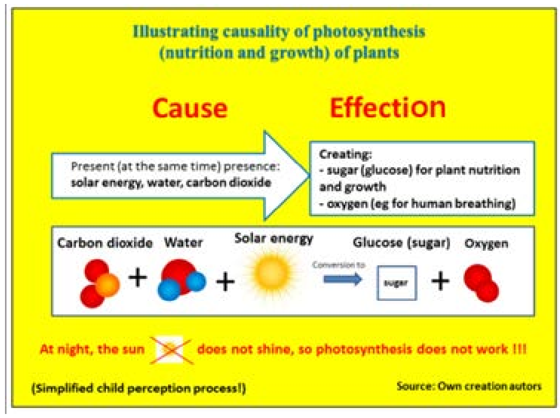

Fig. 5. Structure grams - Illustrating causality of photosynthesis - Cause – Effection (support of the interactive whiteboard).

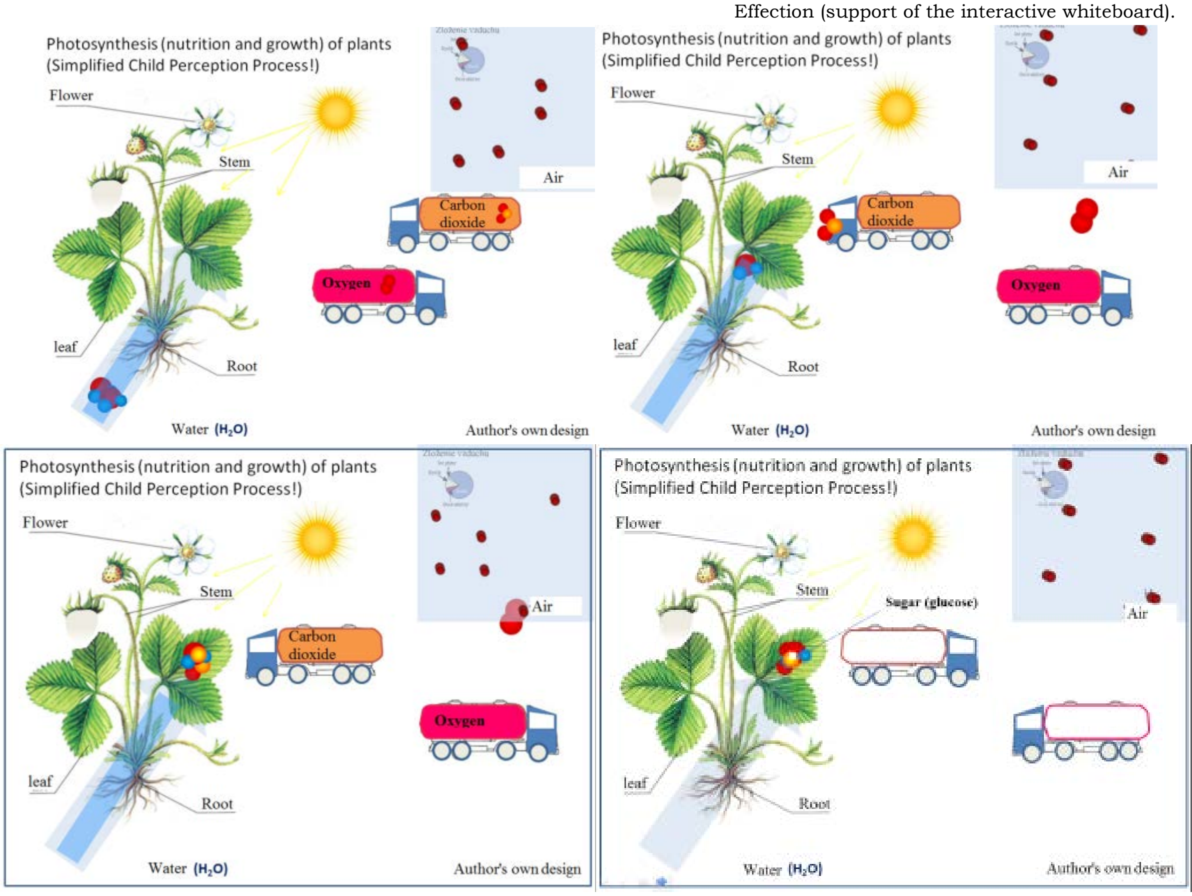

Fig. 6. Key sekvences of Java applet - based on physiological and biochemical nature. (support of the interactive whiteboard) (a).

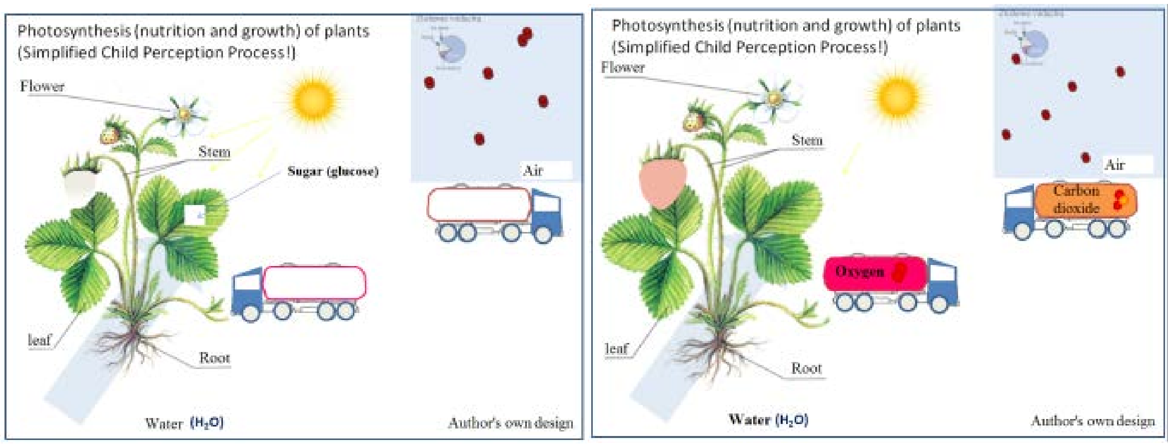

Fig. 7. Key sekvences of Java applet - based on physiological and biochemical nature. (support of the interactive whiteboard) (b).

Running photosynthesis during the day | Running photosynthesis during the night

Fig. 8. Key sekvences of Java applet - Comparison of photosynthesis day and night (support of the interactive whiteboard) (a).

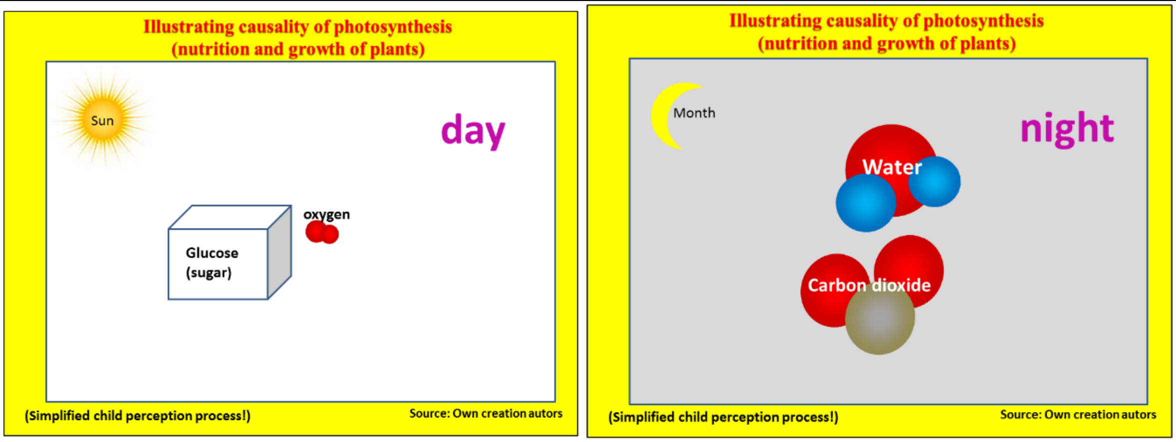

Fig. 9. Key sekvences of Java applet - Comparison of photosynthesis day and night (support of the interactive whiteboard) (b).

The course running of biochemical reactions forming photosynthesis can also be visualized in a virtual way of visualization (with the support of an interactive whiteboard) in other e.g. specific conditions (critical or other input reaction conditions). In essence, it is a display of processes and phenomena occurring under other conditions (most often specific or borderline) using PC simulation. In this way, it is possible to visualize the diversity of the course of photosynthesis during the day and night, but also in individual seasons.

It is even possible to visualize a simplified childhood accessible and attractive more clearly understood by understanding the course of photosynthesis verbally described as follows: Photosynthesis in translation means - folding by light, i.e. more popular and simply called "Gluing" by "Sun". Thus, the notion for children is that the sunbeams here "function as an adhesive for water and carbon dioxide in the form of sugar and oxygen"(Fig. 8-9). This can then lead to a child-friendly explanation of why photosynthesis does not take place at night - because there is no sunlight "that is, glue." Thus, the essence of principle is explained to children in a simple and understandable way.

5. Methodology

The arrival of computer technology has offered unprecedented opportunities for the application of computer simulation and animation in the teaching process. It has raised our awareness of the necessity of a new quality platform creation for visualisation of objects, processes and phenomena in teaching natural subjects.

We made a database of Flash animations (experimental technique of visualisation by means of interactive whiteboard) that served as a platform for the creation of the experimental innovative teaching system called NIESVPH. It designed for visualisation of teaching processes and phenomena through applets. In the process of our research the NIESVPH system (in the form of concrete models designed for teaching selected thematic sections in teaching was also experimentally verified. The method of pedagogical experiment used to compare the two teaching systems in the experimental group (the NIESVPH system) and the control group (traditional teaching system). The principle of the pedagogical experiment is demonstrated in Table 1.

The main aim of the experimental research was to investigate the possibilities of the NIESVPH system application in order to increase the effectiveness of the teaching process.

Table 1. The principle of the pedagogical experiment.

Common Features	
In both the experimental and control groups an identical natural object, phenomenon, or process were visualised	
Different Features	
The control group	**The experimental group**
a **traditional technique** of visualisation using **static pictures** in textbook, transparencies (an overhead projector)	an **experimental technique** of visualisation by means of **interactive whiteboard** (Flash animations and Java applet -computer animation and simulation)

In the experimental group, there was applied the computer supported (using the computer visualization of sing an interactive whiteboard in teaching the theme Table 2 – Breathing and nutrition of plants, fungus - Photosynthesis), there was education carried out without computer support (using traditional way of teaching).

Table 2 Thematic units taught in pedagogical experiment.

Thematic units	**Electronic version -Applets, structure grams** (visualisation by means of interactive whiteboard**)**
Breathing and nutrition of plants, fungus	**Structure grams** - Photosynthesis (Cause - Effect In), How photosynthesis works, Photosynthesis during the day and at night, Photosynthesis and seasons.

H: The initial hypothesis: the proposed experimental teaching system (hereinafter NIESVPH) will be more effective than the traditional teaching system. In order to be able to conduct successful quantitative and qualitative verification we divided the initial hypothesis into the following sub hypotheses:

H1: The cognitive learning performance (the results of the output didactic test) of the students taught by means of NIESVPH will be better than of those taught traditionally.

H2: At the end of the experimental period the students taught by means of NIESVPH will achieve better or the same level of memory performance in comparison with the students taught in a traditional way (in the subtest N1 of the output didactic - test the learning taxonomies of Niemierko).

H3: At the end of the experimental period, the students taught by means of NIESVPH will achieve better or the same level in knowledge comprehension (in the subtest N2 of the output didactic test - the learning taxonomies of Niemierko) compared with the students taught in a traditional way.

We present here only the central sub hypotheses in the cognitive area.

The research sample consisted of 340 research samples were in educational subject Natural Sciences with didactics for Teacher training programmes in primary education). The basis of results achieved in the input didactic tests divided into experimental and control group. 169 students were placed in the experimental group and 171 students in the control group. Pedagogical experiment carried out from January to June (2017 - 18).

The statistical equivalence of the experimental and control groups was mathematically verified at the beginning of the experiment. Verification was performed by analyzing the variance of the results obtained in the initial didactic test.

In the experimental group, there was applied the computer supported (using the computer visualization of sing an interactive whiteboard in teaching the theme – Photosynthesis), there was education carried out without computer support (using traditional way of teaching).

In the process of our research, the following methods (the method of pedagogical investigation and psychological-pedagogical method) use:

1) the pedagogical experiment, the main method, a two-group model of the experiment (an experimental and a control group) conducted synchronously and simultaneously,
2) didactic tests,
3) the questionnaire method,
4) the method of dialogue,
5) the method of observation.

5.1. The major experimental research analyses results

The statistical interpretation of the research analyses findings is concise as the graphs are explicatory enough – Fig 10 and 11. They include the digital data related the values in question as well as the basic characteristics of the statistical ensembles arranged into the tables. As we find them sufficiently descriptive, we do not provide any additional verbal explanations – Table 3.

Table.3 Descriptive and inductive statistics.

Descriptive statistics (Experimental group)						
TAB 1.1E	XmaxE=	14	XminE=	4	AverageE=	10,207
EXP	test.norm	Yes	Median E=	10	Mode E=	11
Descriptive statistics (Control group)						
TAB 1.1C	XmaxC=	14	XminC=	1	AverageC=	8,216
CON	test.norm	Yes	Median C=	7	Mode C=	6
Inductive Statistics						
Stat. confid. (E-C)	k = 2	nil =	1	ni 2 =	338	
Fkr[95%] = 6,76	Fvyp =	55,27	signifik=	yes		

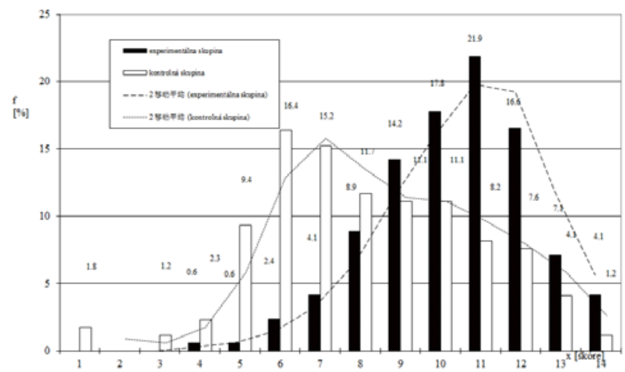

Fig. 10. Frequency distribution of learners' performances achieved in the final didactic test within the pedagogic experiment.

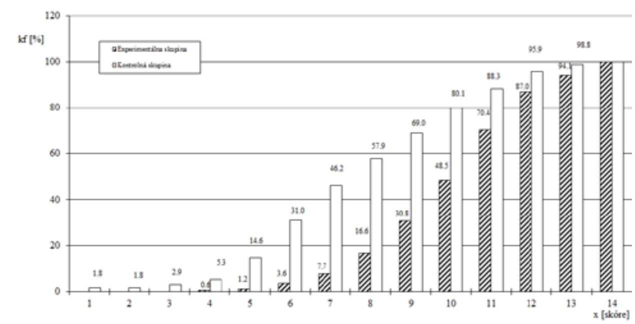

Fig. 11. Distributive function of learners' (scores) achieved in the final didactic test within the pedagogic experiment.

5.2. Some results of the structural statistical analysis on the level of subtests system created on the basis of Niemierko's taxonomy levels of teaching

For a more detailed and targeted analysis of students' performance in the research didactic test (NIESVPH), we divided the tests as a whole into mutually disjunctive subtests. On this platform, we carried out structural statistical analysis at the level of a system of subtests created based on the taxonomy of educational objectives according to Niemierko (remembering, understanding, application).

The student achievements achieved in the N1 subtest in tasks for memorizing the final didactic test in the educational experiment are expressed in the graphs in Fig 12 and 13.

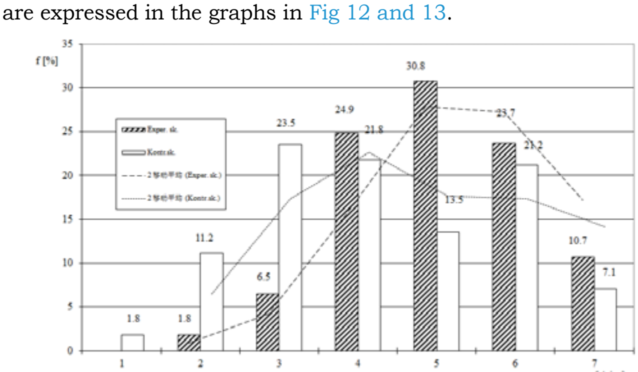

Fig. 12. Frequency distribution of learners' performances achieved in subtest N1 (remembering) of the final didactic test within the pedagogic.

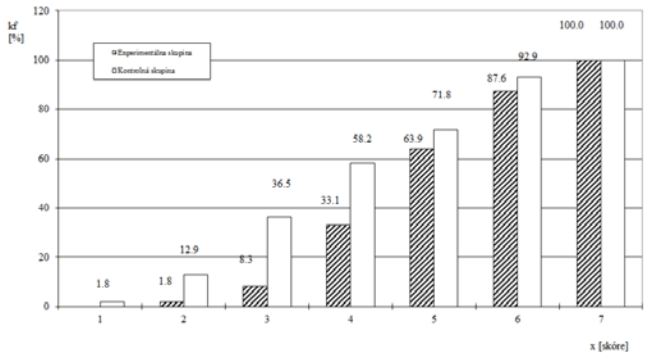

Fig. 13 Distributive function of learners achieved in subtest N1 (remembering) of the final didactic test within the pedagogic experiment.

The students' achievements in the N2 subtest in tasks for understanding the final didactic test in the educational experiment are expressed in the graphs in Fig 14 and 15. The student achievements achieved in the N3 subtest in tasks for the application of the final didactic test in the educational experiment are expressed in the graphs in Fig 16 and 17.

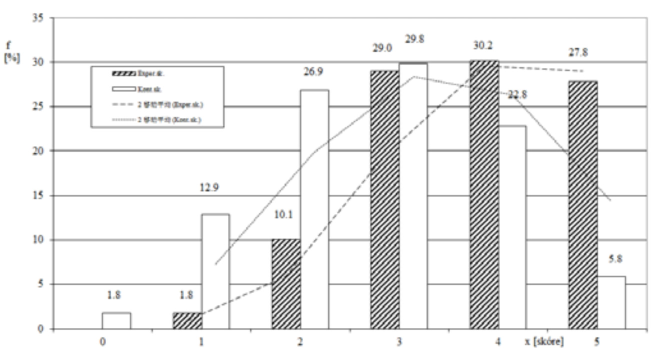

Fig. 14. Frequency distribution of learners' performances achieved in subtest N2 (comprehension) of the final didactic test within the pedagogic experiment.

There are frequency distribution graphs (Fig 13, 15 and 17) of subtests N1, N2 and N3 together with their distribution functions (Fig 14, 16 and 18).

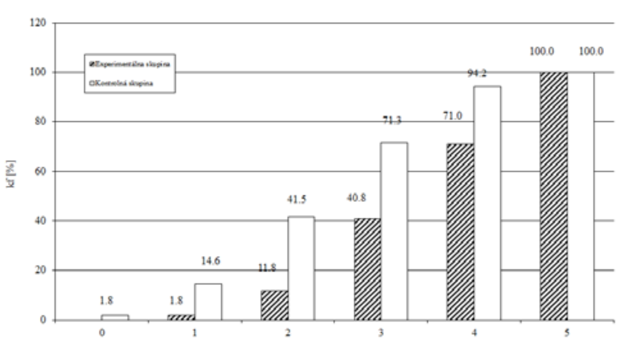

Fig. 16. Distributive function of learners' scores achieved in subtest N2 (comprehension) of the final didactic test within the pedagogic experiment.

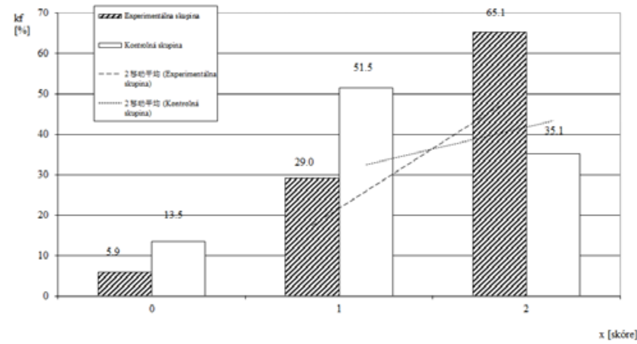

Fig. 17. Frequency distribution of learners' performances achieved in subtest N3 (application) of the final didactic test within the pedagogic experiment.

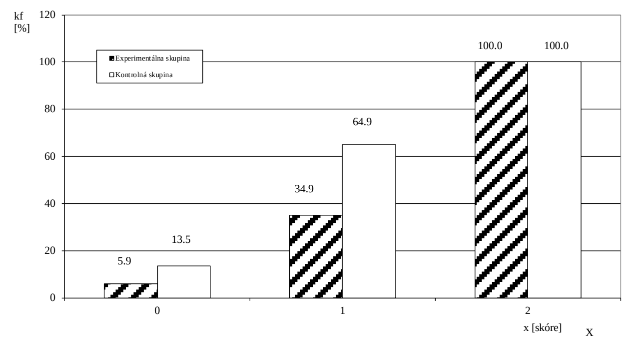

Fig. 18. Distributive function of learners' scores achieved in subtest N3 (application) of the final didactic test within the pedagogic experiment.

We have approximated all of these differences in subtests applied in the pedagogical experiment (NIESVPH) using a moving average (n = 2 and above), (by abrasion technique) iterates well in the case of n → ∞ to Gaussian distribution, which allows us to use inductive statistics (to determine the statistical significance of the difference). The divergence in the form of distributions for the experimental and control groups presented in the graphs on the Fig 11, 12, 13, 14, 15, 16, 17 and 18 can be described as a transformation in the direction of frequency of higher power occurrence in favour of the experimental group. We attribute the changes mainly to the influence of the purposeful effect of the experimental teaching system (NIESVPH) (because we tried to follow all principles of realization of the valid experiment). In addition to the normality criteria applied previously, based on the visual evaluation of the distribution shape in graphical form (especially the visual comparison of mean values and variance, moving average), we also classified the normality of statistical distribution of data using numerical distribution normality criteria (Shapira-Wilka, Agostina).

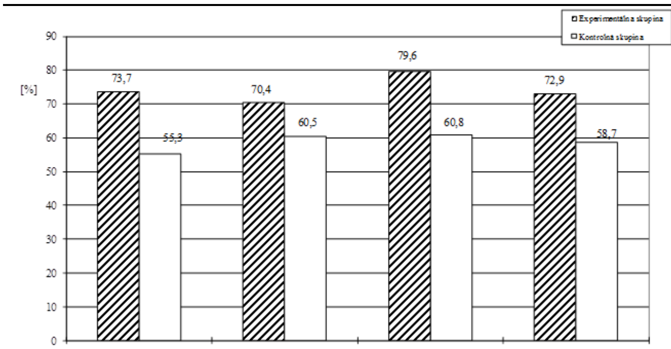

Fig. 19. The comparison of the success rate of the individual subtests assessing the learning objectives (remembering, comprehension, application) in the experimental and control group in the final didactic test.

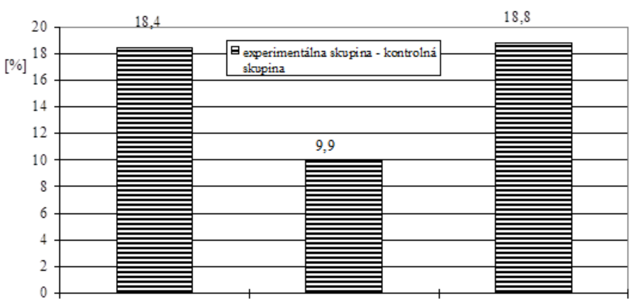

Fig. 20. Difference in the comparison of the success rate of the individual subtests assessing the learning objectives (remembering, comprehension, application) in the experimental and control group in the final didactic test).

5.3. Some results of the quartile and cluster statistical analysis

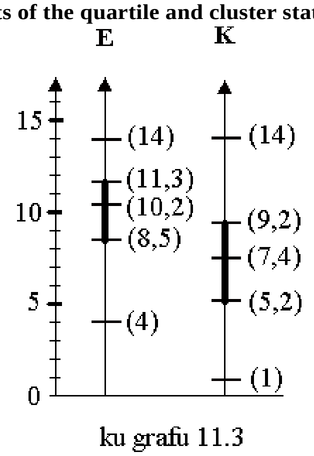

Fig. 21. Results of the quartile and cluster statistical analysis.

5.4. Research results

Based on the statistical verification of the hypotheses of our research, we can list the following research results: Research results of Descriptive statistics (Fig. 13 - 20)

The results show that the differences in the success rate of individual subtests between the experimental and control group are as follows: 9,9 % in remembering, 18,4 % in comprehension, 18,8 %, in application and 15,8 %, in final didactic test application in favour of the experimental group (see Fig. 15, Fig.16). Our statements are listed the results shown in the Table 1, 2 and 3 (Descriptive and inductive statistics). Research results of Inductive statistics (Table 3).

The statistical significance of the performance difference between the experimental and the control group achieved in the final didactic test is demonstrated a whole in the Table 3. Descriptive and inductive statistics (by the analysis of variance – F test). Calculated F was 55,2714, Fkr = 6,76, Since F > Fkr, we can say that in the student's performance achieved in the final didactic test there is statistically significant difference between the experimental and control group at the significance level of 0,05. The interpretation of the subtest results N1 (remembering), N2 (comprehension), N3 (application) is analogical to the previous. (Table 3 Descriptive and Inductive statistics).

5.5. Analysis of phenomenon and discussion finally

We dare to say that the proposed experimental teaching system NIESVPH used during this research appears to be more effective than a traditional teaching system. The students who participated in the experiment showed better performance in cognitive learning as well as in all the other observed parameters (remembering, comprehension, application).

Subtest N1 (memorizing). The results show that the differences in the success rate of individual subtests between the experimental and control group are as follows: 9,9 % in remembering (memorizing). The individual tasks forming the subtest for memorizing knowledge have tested of basic concepts and terminology. (mainly knowledge of schematic chemical symbols as well as the names of chemical elements and compounds, including the symbolic notation of basic biochemical equations with an emphasis on photosynthesis). They solved were well in both the experimental and control groups and the difference in performance in the E (experimental) and K (control) groups was not significant in our opinion.

Subtest N3 (application). The results show that the differences in the success rate of individual subtests between the experimental and control group are as follows: 18,8 % in application. Subtest N3 (application). Regarding the tasks for applying knowledge, the analysis of the responses of this subtest shows that there were significantly more pragmatic and realistic responses in the experimental group compared to the control group. Furthermore, there were no answers very detached from the application reality, and in the answers, one can observe the application overview up to the perspective.

Subtest N2 (comprehension, understanding). The results show that the differences in the success rate of individual subtests between the experimental and control group are as follows: 18,4 % in comprehension (understanding). In the solving tasks of the subtest for understanding has achieved the largest difference between the experimental and control group of all subtests created on the platform of Niemierko taxonomy. We explain this by using the visualization of the course of basic biochemical kinetics of individual biochemical processes and phenomena - Photosynthesis using an interactive whiteboard. In the experimental group was achieved a high degree of clarity.

Experimental group has initiated a platform primarily the knowledge of understanding. We can conclude that based on the results of our research, a high degree of visualization of the processes and phenomena was achieved by the application of simultaneous animation of processes and phenomena taking place in the functional and global plane - structurogram on the physiological biological basis of biochemical phenomena reflecting causality (cause - effect) of Photosynthesis. The processes of biochemical processes in specific conditions with an emphasis on the course of photosynthesis during the day and at night (presence and absence of solar energy) were shown with a particularly high degree of clarity. Moreover, that these processes could be slowed down and stepped in time. To put it simply, the interactive whiteboard made it possible to simultaneously "more dynamic" similarly, the processes of photosynthesis in different seasons were clearly explained, (the application of computer animation and simulation (the ability of processes and phenomena running in biochemical science systems to slow down, accelerate or shred in time, but also to virtualize objects that ca not be seen with the naked eye - they are too small, or large, inaccessible to humans, or real non-existent, etc.).

Finally, we dare to say that the proposed experimental teaching system NIESVPH used during this research appears to be more effective than a traditional teaching system. The students who participated in the experiment showed better performance in cognitive learning as well as in all the other observed parameters (remembering, comprehension, application). 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 educational other subject teacher education. The current results described in our article show that computer-supported learning of natural science subjects in has a positive impact on the acquisition of the educational contents of the natural sciences by school students. The interactive tab, operating on the principle of electromagnetic sensing, which is controlled by an electronic pen, also offers the possibility of dual control. This interactive table use be can also as a classic tab; we can write it with erasable fixes. We can say that a teacher of a subject working on an interactive whiteboard should be creative and creative to be able to capture the most important feature of interactive boards, and that is the simplicity. In particular, this didactic principle can help pupils to motivate new curricula and help them understand the curriculum. In addition to working on an interactive whiteboard, both teachers and students are expanding their knowledge of computer literacy and IT skills. Another important factor is that teachers themselves try to educate themselves in the field of information and communication technologies.

6. Conclusion

Another important factor is that teachers themselves try to educate themselves in the field of information and communication technologies. This article describes some of the options offered by interactive whiteboard software. The slideshow contains all of the illustrative elements such as, for example, Pictures, videos and animations, just need an Internet connection and speaker connections to play audio from videos and sound effects. Teachers in the teaching process with proper use, have effective educational and learning goals. Finally, we can summarize that the interactive table is a modern didactic tool that cannot use in all the topics that is teach in schools. It will but certainly contribute to the teach professional subjects to improve and make more effective the acquisition of pupils' knowledge, skills and habits in the teaching process and is a very good means of motivating pupils and students. The issue of research of innovations in the teaching of natural sciences subjects and also their Didactics can be found described e.g. in foreign periodicals (Li, J.Y. Wang, Wu, Xie, & Jiang, 2019; J.W. Wang, J.Y. Wang, Hu, & Cheng, 2019; Orlik, 2018).

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