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Impact of Electronic Teaching Materials on Process of Education – Results of an Experiment

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Abstract. In their paper the authors deal with the vital issues of creation and application of electronic teaching materials for natural science subjects teaching. They describe an experimental examination of qualitative impact of these aids on education. The authors present a part of research results, which they obtained in a major research focused on possibilities to influence students' attitudes and approaches to particular subjects, mainly the less favorite ones. To be more specific they deal with possibilities to eliminate students' very negative attitude to physics. Their target group were 17–19 aged students and the means applied to change the attitudes of this group to physics were specially designed multimedia education materials and interactive flash animations *Principles of Geometry Optics* covering basic topics from geometry optics.

Keywords: electronic teaching materials, interactive flash animations, multimedia supported teaching, pedagogical experiment, reliability/item analysis, Kruskal–Wallis ANOVA, median test.

1. Introduction

Interest in natural science study has constantly been falling during the last decades not only in Slovakia but also abroad. This tendency is usually presented in connection with a statement about increasing unpopularity of such subjects as physics, chemistry, mathematics and increasing popularity of humanities, social sciences and art subjects and within them mainly popularity of foreign languages. We agree with a currently proclaimed idea of humanization of education. But the humanization of education cannot be developed at the expense of natural science knowledge. Also within the humanization of education the merit of natural science and technical education has to be preserved as an important part of culture, and appropriate and rational world understanding. It is clear that each learner is motivated to learn knowledge from various subjects in his/her own extent and own way. A learner can come to school and s/he can already be motivated to learn and acquire new knowledge, but the learning motivation usually results from school environment and school climate, i.e., from the level and quality of the components of

school environment. So if the interest in natural science study is really on decrease we can put this in connection with the decrease of popularity, or increase of unpopularity, and increase of pupils and students‘ negative attitudes to these subjects. But alike we can give this in connection with an insufficient application of motivation aspects in teaching which would elicit learners‘ interest in these subjects. Let us think and compare the range of new modern and attractive teaching aids for foreign language teaching currently used in schools, and the range of new modern teaching aids for promotion of natural science teaching attractiveness. Let us think about how often and in what ways we persuade our pupils and students how useful and helpful the knowledge of foreign languages is for their life and career, and how often and in what ways we persuade them about necessity and applicability of knowledge gained by learning natural sciences.

Nowadays mainly modern information technologies with integrated audiovisual elements and a great interactivity degree have been used to increase the efficiency of teaching process. The term *computer assisted teaching* has already become a fully accepted pedagogical notion for a long time. But much more frequently we can meet the notion *computer assisted foreign language teaching* than the term *computer assisted natural science teaching* (or to be more specific, computer assisted physics teaching, maths teaching, chemistry teaching, biology teaching). This also shows something about the intensity how humanity science subjects teaching has been made attractive in comparison with natural science teaching (Záhorec and Hašková, 2009).

On the basis of the above mentioned facts we started to deal with possibilities to eliminate pupils and students‘ negative attitudes to natural science subjects which are the most unpopular among the youth. We stated a research hypothesis in which we predicted that *electronic aids assisted teaching contributes the elimination of negative attitudes to school subjects, in particular the subject physics.*

2. Starting Points of the Research

In the mid nineties of the last century (1995–1996) V. Šebeň and R. Jakubov carried out a survey the aim of which was to find out, whether there were any changes in the attitude of learners (lower secondary school) to the school subject physics during the last ten years. The survey was a continuation of the research carried out by V. Šebeň and M. Mlynár in mid eighties (1984–1985) aimed at some issues connected with the ways of increasing interest in physics and motivation to study it (Šebeň and Jakubov, 1997). The research results (1984–1985) showed that increased interest in physics is closely connected with the work with various appliances, aids and experiments. The experiments proved themselves to be stronger motivation in relation to boys and less bright pupils (pupils with low performance and worse marks) in comparison with girls or brighter pupils (pupils with a high level of their performance and achieving good marks). In the case of the brighter pupils learning, acquisition of new knowledge, understanding subject matter and its importance for practice and further education were the factors which highly and positively influenced motivation of learners. When explaining the new teaching material the strongest motivation of learners was the motivation making use of learners‘ experience, motivation based

on the learners' desire to learn new things. Despite the common belief that introduction of problem tasks into teaching makes it more attractive for pupils, motivation based on introduction of the problem tasks was not proved. A negative finding of the research was that in connection with physics all kinds of physics testing was the reason why the pupils experienced various kinds of fears, worries, and frustration. On the basis of the same research questionnaire as it was used in the research carried out in the years 1984–1985 Šebeň and Jakubov were trying to find the answer on the question which motivation factors were vital and dominated in formation of a positive attitude of learners to physics and which of them had negative influence on them. The results of this comparative survey were not at all pleasing. They showed that popularity of physics among pupils has decreased even more within the last ten years (1985–1995). Physics became even less interesting and more difficult for pupils and the other of less pleasing findings was also the fact that motivational potential of appliances and other teaching aids decreased and that experiments almost stopped to elicit interest of learners in physics (especially girls). On the other hand one of the positive findings was the raise of interest in solving physics tasks and heuristics discussions were found as one of the efficient methods of explanation of new study materials. In comparison with the results of previous research, the fears of learners from written testing were not so high any more but the fears of learners from oral testing in front of the class increased a lot. This result may, however, have some connection with the fact that in the first research (1984–1985) one of the very important motivation factors of learners was acquisition of knowledge and its use in their further studies and in practice, whereas in the second research (1994–1995) the top motivation factor of learners was obtaining the best marks.

Rising interest in study materials and motivation for their understanding and learning is the basis of the psychological insurance of study process. This should be based on creation of positive emotional attitude to the contents (themes and topics) of study materials. To regulate emotions for learning activities we can exploit various elements. These elements could be elements of competition, elements of success, presentation of musical-psychological or art-aesthetic elements or the use of vitally popular and attractive phenomena into teaching process. From our point of view the fundamental elements to create emotionally creative learning situations are the elements of novelty, popularity and attraction, and new information and communication technology and multimedia technology still has these elements for the youth. When introducing them into teaching process they emphasize their direct influence on the increase of education impact on learners and on the increase of didactic efficiency of forms and methods of teaching (e.g., Burgerová, 2003). Less attention is paid to possibilities to use the information and communication technology for rising interest in study a particular subject. Current information and communication technologies and multimedia – besides the fact that they create natural environment of the present youth – still have some fascination strength for the youth (what in ten years does not have to be the same). This fascination strength and popularity of information and communication technology among the youth we tried to use to lower or eliminate the incredibly low popularity of some school subjects, namely the one which is the least popular and it is physics.

Our presupposition that teaching aided by electronic teaching aids contributes to lower negative attitudes of learners to school subjects was not just an intuitive issue. It can be confirmed by such results of the research of the influence of information technologies and information competencies of teachers on attitudes of learners to their process of learning as T. Nagy, M. Kubiatko and S. Nagyová carried out (2008). This research was carried out in two phases. The first one was carried out in the years 2000–2001 and the second one in the year 2007. During the years 2000–2001 the sample of 240 teachers from all over Slovakia were retrained in the use of information and communication technologies in teaching process and subsequently, in the year 2007, they observed the attitudes and opinions of 659 learners – from the schools from which the teachers were retrained in the years 2000–2001 – on the issues of the use of information and communication technologies in the process of education and in their further professional career.

The main objective of our research was – as we have already said – the proof of the possibilities to use multimedia aided teaching to eliminate very low popularity of some school subjects, and in our case we focussed our attention on physics as one of the least popular subjects (Záhorec, 2008).

3. Methodology of the Research

To verify the above-mentioned hypothesis we used a pedagogical experiment. Within the experiment we observed and evaluated a possibility to influence students‘ negative attitudes to physics by means of a pedagogical intervention through introduction of multimedia teaching materials developed by us for the purpose of the research.

The research consisted of following activities:

1. Development of the experimental teaching materials. Development of a questionnaire for the purpose of research data collection.
2. Assessment of the research tools quality – reliability/(questionnaire) item analysis.
3. Creation of both experimental and control group.
4. Administration of the questionnaire.
5. **Experimental plan realization.**
6. Re-administration of the questionnaire.
7. Evaluation of the created electronic products *Principles of Geometry Optics.*
8. Exploration analysis of the collected data.
9. Validity verification of the used statistics method.
10. Data analysis.
11. Research data interpretation.

Development of the electronic teaching materials and of the animated (flash) presentations *Principles of Geometry Optics* for selected parts of physics curricula was the first but logically the most important step to reach the intended goal of our pedagogical intervention. The main attention was paid to visualisation of the presented physical concepts (notions) and relations which was achieved through a big number of (flash) animations and interactive simulations of various optical phenomena (Záhorec *et al.*, 2008).

The pedagogical experiment was carried out during the academic year 2007/2008 at a higher secondary (comprehension) school in Nitra (Gymnazium Golianova ul.). The research sample formed students attending the final grades of their study at the school (4th grade students of a four-year type of the school and 8th grade students of an eight-year type of the school), i.e., the research sample consisted of representatives of 17–19 year aged youth. The group included 82 students out of which boys were 58.5 % and girls were 41.5 %. Pedagogical intervention of our teaching materials into teaching process was carried out during regular physics lessons and seminars.

Research data were collected by means of a questionnaire *Investigation of students' attitudes to the school subject physics,* which was designed specially for the purposes of our research. By means of this questionnaire we estimated the level of physics popularity among students (of the given age) and the extent of the students' interest in studing physics.

In the questionnaire the respondents expressed their attitudes on a seven-point scale. The smaller was the indicated value of the scale the greater was the expressed negative attitude, and the greater was the indicated value of the scale the stronger was the positive assessment (1 – full negation, 7 – full acceptance). The questionnaire was administrated twice. The first time it was like a pre-test before the pedagogical experiment (introduction of the designed multimedia materials into teaching) and the second time like a post-test after the completion of the experiment (after a longer use of the designed multimedia materials). For each student we recorded the scale value s/he marked at each questionnaire item in both pre-test and post-test. Moreover we recorded also marks the students obtained at the end of the 3rd or 7th grade of their study, which represented another ordinal variable (study results from physics).

To assure the quality of the measurements through which the research data are collected, the measuring process must be objective, reliable and valid. That is why one of the steps of our research was to verify reliability of the administered questionnaire *Investigation of students' attitudes to the school subject physics* and to identify suspicious items (items which lower the questionnaire reliability). To test further problems we have to assure that we are able to estimate influence of quality of the measuring procedure on our experimental data/results.

3.1. *Analysis of the Questionnaire/Items Reliability*

To analyze questionnaire reliability we have used techniques and methods to assess questionnaire reliability and to identify suspicious items. From the correlation matrix presented in Table 1 we can identify suspicious items of the questionnaire. Highlighted correlation coefficients are statistically important on the significance level 0.05.

In the correlation matrix (Table 1) we can see that most values are statistically important for most of the items. This means that there is a certain interdependence among these items. The closer the correlation coefficient is to the value $1/-1$, the stronger is the proportional dependence. Some exceptions are the items 2 and 3 between which the correlation is not statistically significant. This means that the items are independent. Based on this, these items seem to be suspicious ones.

Table 1
Correlation matrix of pre-test items

	1PRE	2PRE	3PRE	4PRE	5PRE	Mark (physics)
1PRE	**1.000**	0.602	0.245	0.447	0.371	−0.335
2PRE	0.602	**1.000**	**0.099**	0.372	0.486	−0.167
3PRE	0.245	**0.099**	**1.000**	0.314	0.196	−0.199
4PRE	0.447	0.372	0.314	**1.000**	0.282	−0.335
5PRE	0.371	0.486	0.196	0.282	**1.000**	**−0.033**
Mark (physics)	−0.335	−0.167	−0.199	−0.335	**−0.033**	**1.000**

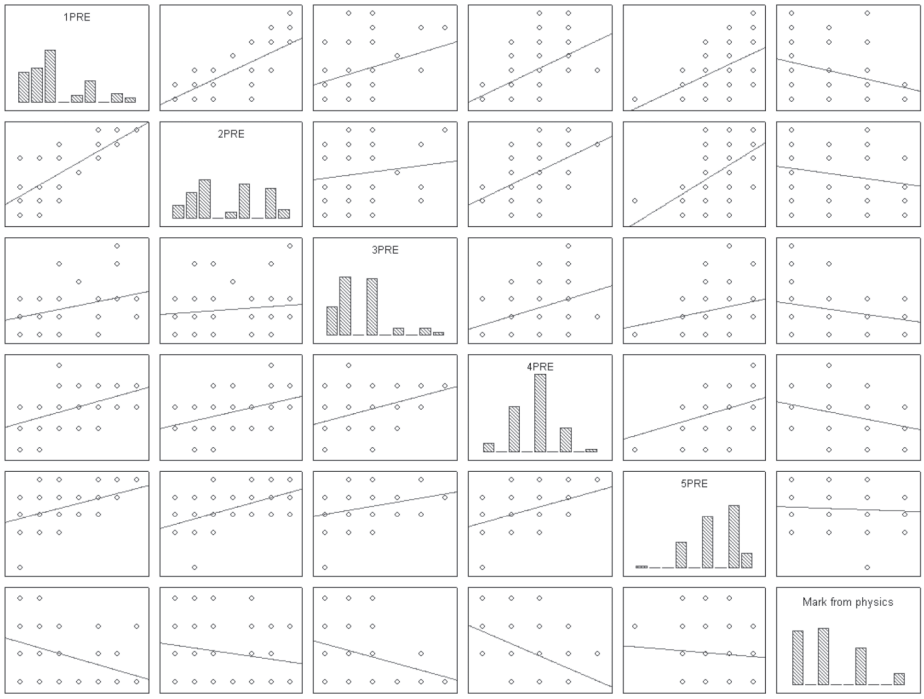

Fig. 1. Matrix chart – visualization of the correlation matrix.

There is a negative correlation between *Study Results from Physics/Mark (Physics)* and all the other items, i.e., the values are changed simultaneously, but in a reverse order (while one variable value decreases the other variable value increases).

The correlation matrix of the pre-test particular items presented in Table 1 is visualized in a matrix chart in Fig. 1.

Each correlation coefficient is expressed by a scatter plot. Unit values on the diagonal are replaced with a histogram, which expresses shape of the variables distribution. In the case of a directly proportional dependency (values changing in the same direction) an increasing line is interpolated through the points of the scatter plot, in the case of an

Table 2
Overall statistics of the questionnaire (pre-test)

No of questionnaire items		5	
No of valid cases		73	
Average	16.534	Sum	1207.000
Decisive offset.	4.673	Diffusion	21.836
Minimum	6.000	Maximum	28.000
Cronbach's Alfa	0.768	Standardiz. Alfa	0.782
Average correlation between items		0.431	

Table 3
Questionnaire statistics (pre-test) after elimination of the suspicious item

	Mean if deleted	Var. if deleted	StDv. if deleted	Itm.-Totl. Correl.	Alpha if deleted
1PRE	13.548	11.261	3.356	0.731	0.646
2PRE	12.589	10.790	3.285	0.657	0.692
3PRE	14.096	17.676	4.204	0.314	0.789
4PRE	13.753	17.035	4.127	0.570	0.735
5PRE	12.151	16.155	4.019	0.578	0.724

indirectly proportional dependecy (values changing in the opposite direction) a decreasing line is interpolated through the points of the scatter plot and in the case of the values independence there is a constant line (values do not change jointly in any direction).

Reliability coefficient value 0.77 (77 %) expresses extent of variability of total sum of scale items to total questionnaire variability. Results of both estimations (Cronbach's Alfa and standardized Alfa) are similar, i.e., particular items have identical variability (Table 2).

As it follows from the presented results, the questionnaire can be considered reliable. However. a low average correlation between the particular items shows that after elimination of certain items the reliability of the questionnaire could be increased.

Table 3 shows that all pre-test items correlate with the scale total score. After the elimination of the second item the reliability coefficient dropped. The third item activates an opposite phenomenon – in its case, the reliability coefficient value increased.

Analysis of the post-test reliability has proved results of the pre-test reliability analysis (Munk and Záhorec, 2009).

After the elimination of the 3rd item value of the reliability coefficient Cronbach's Alfa increased from 0.77 to 0.79. This shows that the 3rd item decreases the total questionnaire reliability. That is why we performed a deeper analysis of the suspicious item No 3, i.e., the item after elimination of which the questionnaire reliability increased.

Item No. 3: *Physics is a school subject which for me is:*
7 – very easy
6 – easy
5 – rather easy
4 – neither difficult nor easy
3 – rather difficult
2 – difficult
1 – very difficult

The aim of the third item was to find out how difficult students find the subject physics taught at higher secondary (comprehension) schools. We expected that in this item students would express their clear and definite opinion about the subject difficulty reflected in the educational content of physics determined in the school curriculum. By means of statistic methods we achieved interesting findings. Scale measurements showed that this item belonged to those with the most diverged answers. The elimination of this item resulted in a significant (the highest) increase of the questionnaire reliability coefficient. This item decreased the reliability of the whole questionnaire because also those students, who agreed in the other items that physics belonged to their rather favourite subjects or that it was an interesting and important subject, considered it to be difficult in this item. Almost 2/3 of all respondents of the pedagogical experiment chose the alternative *rather difficult* (3), *difficult* (2) or *very difficult* (1).

3.2. *Methodology of the Pedagogical Experiment*

The experiment we carried out in the frame of our research was based on a pedagogical intervention of the experimental materials into the teaching process. There were three groups involved in the pedagogical experiment:

1. Experimental group A (hereinafter ESA)

This group was formed from students of 8th grade (Octave B-OKB) of the eight-year type of the higher secondary school (Gymnazium Golianova ul., Nitra) attending a class with extended informatics and programming teaching curriculum. During the experiment teaching physics in this group was based on the utilization of a visual multimedia support, which consisted of computer animations and interactive simulations of teaching materials *Principles of Geometry Optics* developed by us for the purpose of the research. The animations and simulations make it possible to present the taught issues and phenomena as well as difficult to imagine abstract and theoretical problems in a more visual way.

2. Experimental group B (hereinafter ESB)

This group was formed from students of 8th grade (Octave A-OKA) of the eight-year type of the higher secondary school attending a class with extended foreign language teaching curriculum. During the experiment the learners of this group were expected to acquire the knowledge from the appropriate areas of geometry optics based on a utilization of some visual multimedia support but in this group was used a teaching material *Physics Teaching Supporting Teaching Presentations* (author Jozef Beňuška) provided on CD.

3. Control (comparison) group (hereinafter KS)

This group was formed from students of 4th grade (4.C) of the four-year type of the higher secondary school attending a class with extended informatics and programming teaching curriculum. In this group the given topics of geometry optics were taught without any intervention of the experimental multimedia materials into teaching process. Explanation of the topics was provided in a usual standard way in a common classroom, based on the standard physics text-book for 4th grade of higher secondary (comprehensive) schools.

More details about the composition of the particular research groups are presented in Table 4 and the scheme of the pedagogical experiment is given in Table 5.

The knowledge level of students involved in the particular research groups (ESA, ESB, KS) was not the same. But for the purpose of our research this fact did not make any difference. The group differences were in no conflict with research correctness as we observed possibilities to influence students‘ attitudes to physics through a pedagogical intervention of electronic teaching materials into the teaching process, and we did not observe teaching efficiency improvement.

Changes in students‘ attitudes to physics due to the electronic teaching materials intervention into the teaching were evaluated by means of statistical methods processing data obtained from the questionnaire D (*Investigation of students' attitudes to the school subject physics*) and its repeated administration before and after the pedagogical experiment (as a pre-test and post-test).

Table 4

Composition of the experimental groups A (ESA) and B (ESB) and the control group (KS)

Group	Experimental group A (ESA)	Experimental group B (ESB)	Control group (KS)	
Grade	8. (8-year study)	8. (8-year study)	4. (4-year study)	Total
Boys	18	6	18	42
Girls	8	18	5	31
Total	**26**	**24**	**23**	**73**

Table 5

Scheme of the pedagogical experiment

Experimental group	Pre-test	Kind of the pedagogical intervention	Post-test
ESA	D	VMPV, MUMZGO	D
ESB	D	VMPV, MCD	D
KS	D	KKV, KTU	D

Explanations: KS = control group, ESA = experimental group A, ESB = experimental group B, KKV = standard contact teaching, VMPV = teaching with a visual multimedia support, KTU = teaching with a common text-book, MUMZGO = teaching supported by the multimedia teaching material *Principles of Geometry Optics*, MCD = teaching supported by the CD multimedia teaching material *Physics Teaching Supporting Teaching Presentations*, D – questionnaire *Investigation of students' attitudes to the school subject physics.*

4. Data Analysis of the Research Results

From the research data obtained from administration of the above-mentioned questionnaire D *Investigation of students' attitudes to the school subject physics* before (pre-test) and after (post-test) the pedagogical experiment realization we had at our disposal pre-test and post-test results of the experimental group ESA (26 students), experimental group ESB (24 students) and control group KS (23 students). In the questionnaire item 1 the respondents evaluated physics as their favourite or unfavourite subject (1 – *very unfavourite*, 7 – *very favourite*). In the item 2 they evaluated attractiveness of physics content (1 – *very uninteresting*, 7 – *very interesting*). In the item 3 they evaluated difficulty of physics acquisition (1 – *very difficult*, 7 – *very easy*). Whereas in the item 3 the respondents evaluated difficulty of physics acquisition in general, in the item 4 they indicated whether they understand presentation of the subject matter by their teacher (1 – *I almost never understand*, 7 – *I understand almost always*). In the item 5 the respondents were asked to assess physics importance for everyday life and as a part of a human education (1 – *completely meaningless*, 7 – *very meaningful*). Next three questionnaire items were closed. From the alternatives on offer the respondents chose the one which fit the best with their personality and which presented the best their attitude to physics (item 6 – *There are various reasons why students learn particular subjects, what is the reason why you learn physics*; item 7 – *Different students prefer different ways of new subject matter explanation, what kind of explanation do you prefer*; item 8 – *Some students feel some fear before physics lesson, what is a source of your fears*).

Pre-test Data Analysis

On the basis of descriptive statistics following null hypotheses were stated:

1. H0: Response to the item 1PRE does not depend on the factor GROUP.
2. H0: Response to the item 2PRE does not depend on the factor GROUP.
3. H0: Response to the item 3PRE does not depend on the factor GROUP.
4. H0: Response to the item 4PRE does not depend on the factor GROUP.
5. H0: Response to the item 5PRE does not depend on the factor GROUP.
6. H0: Response to the item 6PRE does not depend on the factor GROUP.
7. H0: Response to the item 7PRE does not depend on the factor GROUP.
8. H0: Response to the item 8PRE does not depend on the factor GROUP.

Because the stated null hypotheses were not rejected for the pre-test items, the particular groups participating in our pedagogical experiment can be considered as equivalent. Results of the pre-test data analysis proved that all three groups of the respondents (experimental group A, experimental group B, control group KS) were the same as to the possibility to influence students' attitudes to the school subject physics by means of a pedagogical intervention of electronic teaching materials *Principals of Geometry Optics,* which we designed. The above-mentioned allowed us to state that a differentiation of the groups from a point of view of their study orientation (on informatics and programming or foreign languages) as well as their differentiation according the study duration (four-year or eight-year higher secondary/somprehensive school) was irrelevant.

Post-test Data Analysis

On the basis of descriptive statistics the following null hypotheses were stated:

1. H0: Response to the item 1POST does not depend on the factor GROUP.
2. H0: Response to the item 2POST does not depend on the factor GROUP.
3. H0: Response to the item 3POST does not depend on the factor GROUP.
4. H0: Response to the item 4POST does not depend on the factor GROUP.
5. H0: Response to the item 5POST does not depend on the factor GROUP.

To be brief we present as an example of the research data processing and evaluation only results related to the analysis of the post-test items 1 (factor 1POST – physics popularity) in detail and further we concentrate more only on a total interpretation of the obtained research results.

H0: Response to the item 1POST does not depend on the factor GROUP.

On the basis of the Kruskal–Wallis test it resulted: $H(2, N = 73) = 11.80656$, $p = 0.0027$, so we rejected the null hypothesis ($p < 0.05$) stating that the difference among the groups in evaluation of the post-test first item is not statistically significant, i.e., the dependent variable 1POST depends on the factor GROUP.

Results of the Median test: chi square = 11.54727, df = 2, $p = 0.0031$. proved the results of the Kruskal–Wallis test ($p < 0.05$).

Rejecting the hypothesis H0 we asked the question:
Which are the groups between which there is a statistically significant difference?

Results of multiple comparisons of mean ranks for all groups are presented in Table 8.

Table 6
Kruskal–Wallis test for item 1POST

	Valid N	Sum of ranks
ESA (OKB)	26	1255.000
ESB (OKA)	24	743.500
KS (4.C)	23	702.500

Table 7
Median test for item 1POST

	ESA (OKB)	ESB (OKA)	KS (4.C)	Total
<= Median: observed	7.000	17.000	15.000	39.000
Expected	13.890	12.822	12.288	
obs.-exp.	−6.890	4.178	2.712	
> Median: observed	19.000	7.000	8.000	34.000
Expected	12.110	11.178	10.712	
obs.-exp.	6.890	−4.178	−2.712	
Total: observed	26.000	24.000	23.000	73.000

Table 8
Multiple comparisons for item 1POST

	ESA (OKB) R:48.269	ESB (OKA) R:30.979	KS (4.C) R:30.543
ESA (OKB)		**0.012**	**0.011**
ESB (OKA)	**0.012**		1.000
KS (4.C)	**0.011**	1.000	

Table 9
Chi square test for item 8POST

	chi-square	df	p
Pearson chi-square	21.346	df = 12	p = 0.046

Statistically significant differences are among the first experimental group (ESA) and the other two groups (ESB, KS) ($p < 0.05$). Results of multiple comparisons for the post-test first item are processed in a box & whisker plot (Fig. 4).

Similarly as the null hypothesis H0 for the item 1POST was rejected the null hypotheses for the other items 2POST – 5POST were rejected, too. So our research hypothesis

We predict that electronic teaching means assisted teaching contributes to elimination of negative attitudes to school subjects, concretely to the subject physics.

was affirmed.

Following null hypotheses were:

6. H0: Response to the item 6POST does not depend on the factor GROUP.
7. H0: Response to the item 7POST does not depend on the factor GROUP.
8. H0: Response to the item 8POST does not depend on the factor GROUP.

Differences among the particular group answers were affirmed only in the case of the 8th item. From this reason we present only this item analysis.

H0: Response to the item 8POST does not depend on the factor GROUP.

Table 9 shows that relationship between the post-test 8th item evaluation and the group, which the respondent is a member of, is statistically significant ($p < 0.05$), i.e., evaluation of the post-test 8th item depends on the factor GROUP. As it follows from the chi square test results the contingency coefficient value 0.476 is statistically significant and it is the biggest value in comparison with the other contingency coefficients (6PRE×GROUP, 7PRE×GROUP, 8PRE×GROUP, 6POST×GROUP, 7POST×GROUP).

Chi square test results are presented in an interaction plot in Fig. 3. The interaction plot affirms chi square test, response curves for particular groups are depicted in different ways.

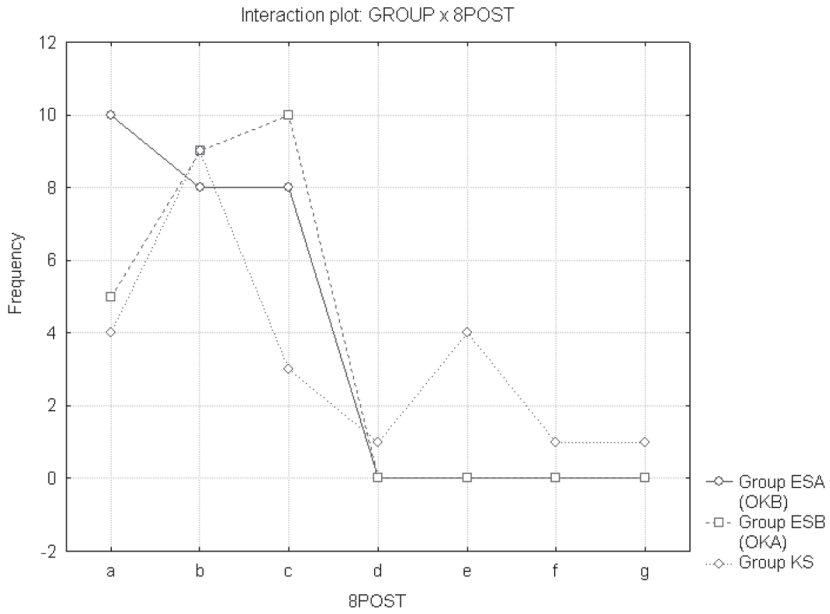

Fig. 2. Interaction plot of frequencies for item 8POST.

Explanation: Item 8: *Some students feel some fear before physics lesson, what is a source of your fears:*

a) *I am not used to be afraid of anything.*
b) *Lack of preparation for the lesson.*
c) *Oral examination.*
d) *5 minute written tests.*
e) *Getting a bad mark.*
f) *Fear that I will not again understand the presented subject matter.*
g) *Other – please, specify.*

5. Interpretation of the Research Results

Results of the post-test data analysis were very similar for all five items 1POST–5POST (popularity of physics, physics content attractiveness, difficulty of learning physics, comprehensibility of physics teacher explanation, physics importance for everyday life and one's education). They proved that due to the use of the multimedia materials in teaching process the degree of the students' negative attitude to the subject physics significantly decreased in all the observed aspects (1POST–5POST, see the box & whisker plots in the Figs. 3–12; it was proved that all variables 1POST–5POST are dependent on the factor GROUP).

Of course, we do not affirm, that the use of the multimedia teaching materials changed physics from a very low popular subject to a favourite one. We affirm (and the research results prove it) that this type of teaching has resulted in an elimination of the students' negative attitude to physics, i.e., after the pedagogical intervention of the experimental electronic teaching materials the students' attitude to physics was not so negative as it was before. Here we have to admit that it is very difficult to change one's opinions, atti-

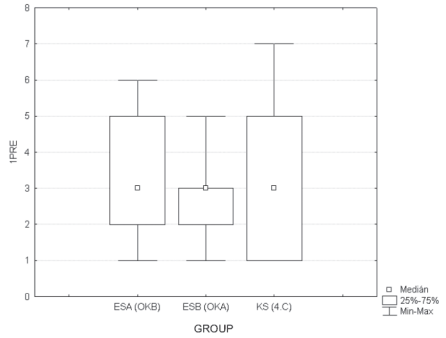

Fig. 3. Box & whisker plot for item 1PRE.

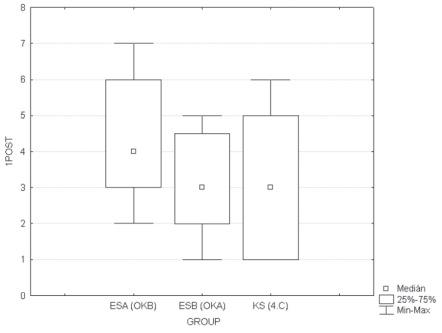

Fig. 4. Box & whisker plot for item 1POST.

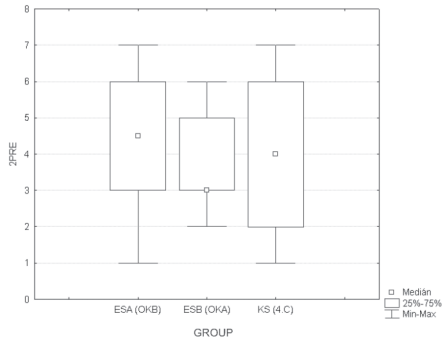

Fig. 5. Box & whisker plot for item 2PRE.

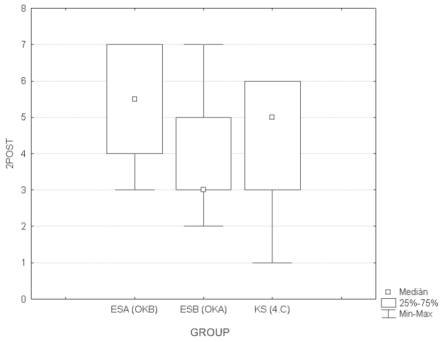

Fig. 6. Box & whisker plot for item 2POST.

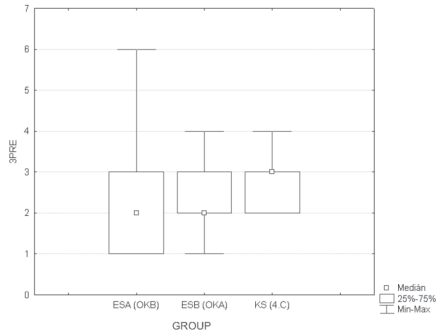

Fig. 7. Box & whisker plot for item 3PRE.

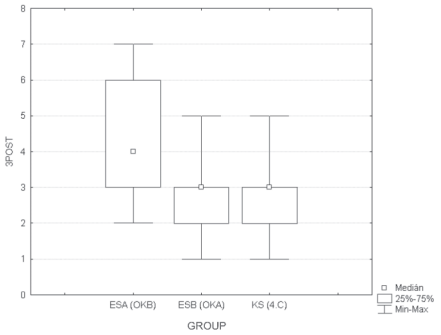

Fig. 8. Box & whisker plot for item 3POST.

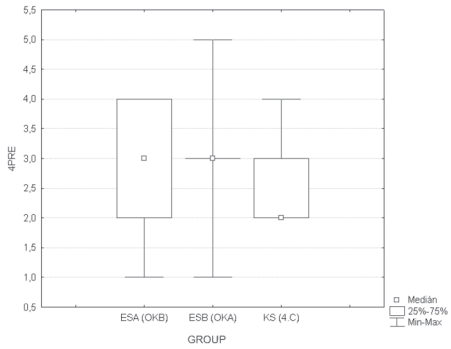

Fig. 9. Box & whisker plot for item 4PRE.

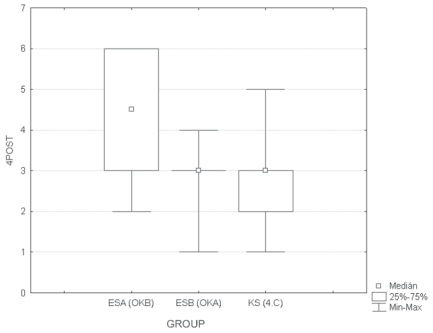

Fig. 10. Box & whisker plot for item 4POST.

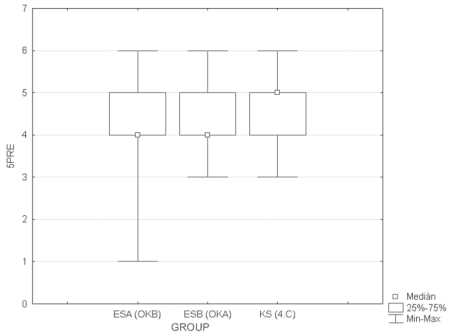

Fig. 11. Box & whisker plot for item 5PRE.

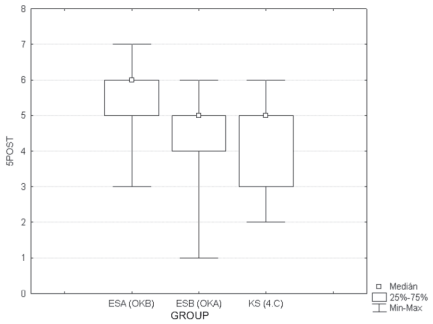

Fig. 12. Box & whisker plot for item 5POST.

tudes and approaches. Usually it takes longer time and the duration of our influencing the learners (duration of the pedagogical experiment) was only 3 months. On the other hand the more significant are the achieved results, i.e., significant shifts in students' attitudes were achieved in quite a short time and we could observe them.

In the case of the item 2POST (physics content attractivenes) a significant difference occurred between the group ESA and the group ESB (Fig. 6). In the case of the other items a significant difference was identified between the group ESA and the other two groups, ESB and KS (Figs. 4, 8, 10, 12). This means that the presentation itself of multimedia demonstrations in teaching process and explanations based on them are not enough to elicite changes in students' attitudes and approaches – this was the case of the experimental group ESB and multimedia teaching material *Physics Teaching Supporting Teaching Presentation* used in it. To elicite the changes, the students must also have the possibility to work with these materials, to have hands-on experience, either at school or at home, as it was in the case of the experimental group ESA and multimedia teaching ma-

terials *Principles of Geometry Optics* used in it where a great amount of flash animations and interactive simulations was available. In the case of the experimental group ESA, in which the teaching process was carried on the basis of the pedagogical intervention of the specially designed materials *Principles of Geometry Optics*, in comparison with the other two groups (experimental group ESB and control group KS) there was recorded a positive shift in the students' evaluations of all the post-test items. Students from this group expressed in post-test a more positive attitude either to popularity of physics or to physics content attractiveness or comprehensibility of physics teacher explanation, even physics importance for everyday life and for one's education and work career.

Taking into account results of the data statistical processing and following analysis of the first five items of the pre-test and post-test (Figs. 3–12) a positive finding in the case of the first experimental group (ESA) is the fact that for these students the minimal and maximal scale values in their assessments in the post-test have arisen about 1–2 scale values to compare with the pre-test results.

From the graphical presentation of the results achieved from the students' answers in the first experimental group (ESA) in the item 1POST (Fig. 4) we can see that the scale median for this item (physics popularity – *Physics is my ...)* is equal the value 4 (*. . .neither favourite nor unfavourite subject*). This means that students in their evaluations expressed a neutral attitude to physics. Before the pedagogical experiment in the administrated pre-test the result in this item was a scale median value equal 3 (*rather unfavourite*). Our prediction, that students would present positive attitudes to this item statement after the pedagogical intervention of the multimedia teaching materials into teaching process, did not confirm as middle 50 % of the assessment values have been within the scale range 6–3 (6 – *favourite*, 3 – *rather unfavourite*) having the scale maximal value 7. But also here a partial elimination of the previous more negative attitude to physics can be seen, as in the pre-test middle 50 % of the assessment values were within the scale range 5–2 having the scale maximal value 7 (5 – *rather favourite*, 2 – *unfavourite*). The fact that our prediction of students' expresion of their positive attitudes to physics did not confirm we relate to the above mentioned fact, that promotion of more radical changes in one's opinions, approaches and attitudes needs a longer time.

In the item 2 (2PRE, 2POST – Fig. 5, Fig. 6) we observed how interesting and attractive physics was for the students. Median of the evaluations given by the students in the pretest, in which they assessed physics attractiveness, was 4.5 for the group ESA, 3 for the group ESB and 4 for the group KS, what means that the students in the group ESA (and more or less also in the group KS) evaluated physics as a subject which was *rather interesting* (5) or *neither interesting nor uninteresting* (4) and the students in the group ESB evaluated it as *rather uninteresting.* In the post-test administrated after the pedagogical experiment in the case of the groups ESB and KS no significant changes occurred but in the case of the group ESA the students evaluated physics attractiveness already as *interesting* or *rather interesting* (2POST median 5.5).

Through the item 3 (3PRE, 3POST – Fig. 7, Fig. 8) we observed whether the pedagogical intervention of the experimental materials caused any changes in students' assessment of learning physics difficulty. Before the pedagogical experiment all three groups

in general evaluated difficulty of the school subject physics on the level *difficult*. 50 % of the assessment values in the item 3PRE in the groups ESB and KS were within the scale range 2–3 having the scale maximal value 7 (2 – *difficult*, 3 – *rather difficult*) and in the experimental group ESA even within the scale 1 – 3 (1 – *very difficult*) and the median value was only 2. In this context we consider the result achieved in the third item of the posttest (3POST) as the most important result of the research we carried out. Although the students' opinions on physics difficulty in the groups ESB and KS were not changed significantly, the situation in the group ESA was completely different. After the pedagogical experiment the students in the group ESA expressed remarkably more positive opinions about difficulty of the school subject physics and 50 % of their answers were within the scale range 6–3 (6 – *easy*, 3 – *rather difficult*) at the 3POST median value 4, what means that after the pedagogical intervention of our experimental teaching materials the group as a whole evaluated physics as subject which is *neither difficult nor easy.* This was the item in which, apart from the surprising result achieved in the fifth item, we recorded the greatest shift in its evaluation before and after the pedagogical experiment. In general, teachers, and mainly natural science teachers, are aware of the fact how difficult it is to explain and to bring closer to students various physics phenomena. But here we can see that the appropriate multimedia teaching aids can serve as an effective instrument. On the other hand it has to be admitted once again that not any multimedia aid and not any way of its use has automatically impact like this. The results of the experimental group ESB, where the teaching process was carried out also with an intervention of multimedia teaching materials but with a lower level of interactivity and with a lower possibility of hands-on activities, confirm this fact.

Besides physics difficulty, the second very often presented reason of physics unpopularity among students is that students do not understand teacher explanation. Unfortunately we have to say that this has also partially proved in our research. In the pre-test 50 % of the students answers in the item 4PRE, in which the students indicated whether they understand physics teacher's presentation of new subject matter, ranged in the scope from 2 to 3 (KS) or from 2 to 4 (ESA) what means the evaluation from *I do not understand very often* (2) to *sometimes I do understand and sometimes I do not understand* (3) or to *I rather understand* (4). The medians for the groups ESA and ESB were 3 (*sometimes I do understand and sometimes I do not understand*) and for the group KS even 2, i.e., *I do not understand very often* (Fig. 9). In the post-test the situation in the groups ESB and KS was approximately the same (Fig. 10). As to the experimental group ESA we can say that the used experimental multimedia teaching materials highly contributed to comprehensibility of the teacher's explanation of the subject matter for the students. After pedagogical intervention of these materials into the teaching process 50 % of the students' assessments of the comprehensibility of the teacher's explanation ranged already from 3 (*sometimes I do understand and sometimes I do not understand*) even up to 6 (*I understand mostly*) and the median value arose to 4.5.

On the basis of the above-presented results we can come to a conclusion that the shift in the students' attitude to the subject physics was achieved due to the increased levels of the comprehensibility of the teacher's subject matter explanation and its attractiveness,

resulted from the pedagogical intervention of the experimental multimedia teaching materials. This more positive assessment of the comprehensibility of subject matter explanation and attractiveness of the physics content we consider to be also a reason of a more positive assessment of the physics importance for everyday life and one's education. In the fifth questionnaire item the students were asked how important they considered to be the subject physics for them. Comparing the results in this item in the post-test (5POST – Fig. 11) with the ones from pre-test (5PRE – Fig. 12) we came to a very satisfying finding for us concerning the experimental group ESA. The scale median of its assessment of the physics importance increased from 4 (*neither meaningful nor meaningless*) even up to 6 (*meaningful*) and at the same time middle 50 % of the assessment values shifted from the scale range 3–5 to the scale range 5–6 (3 – *rather meaningless*, 5 – *rather meaningful,* 6 – *meaningful*) having the scale maximal value 7.

In the 6th questionnaire item the answers of the different groups were the same. The results showed that currently the learners have a very low internal motivation to learning physics knowledge what, according to us, is connected with the fact that they can not see any possibilities how to apply and use this knowledge in their everyday life (see the results for the previous item). That is why also at the school solved physical tasks and experiments do not motivate them to learn physics and the main motivation for them is their effort to gain the best mark they can in this subject. As to the kind of the teacher's explanation of new materials students prefer the situation when the teacher explains the subject matter all by him/herself and to do that, s/he uses various teaching aids. A positive finding is that learners ask for the use of teaching aids but a negative finding is that they do not want to be involved into the process of the new knowledge use.

In the questionnaire item 8 students were asked to indicate the reasons why they feel frightened before physics lesson. The students chose more or less the same response alternatives in the post-test as they did in the pre-test. Comparing interaction plots for 8th item of the post-test and pre-test (Fig. 3) we recorded a slight rise in the alternative $a(Iamnotusedtobeafraidofanything)$ frequency relating to the experimental group A (ESA) what is a positive result. The results show that currently before the physics lessons students are afraid mainly that they will be examined (*c – oral examination*) and they fear that they are not prepared properly (*b – lack of preparation for the lesson*). In contrast, the students' fear of written tests decreased (*d – 5 minute written tests*). The biggest difference in the item 8POST evaluation by students from different groups was registered in case of the response alternative $a(Iamnotusedtobeafraidofanything), c(oralexamination)$ and $e(gettingabadmark)$. Another pleasing finding is the fact that in case of the groups ESA and ESB none of the respondents chose the possibility e on the contrary with the group KS.

6. Conclusions

The results of our research proved validity of the stated hypothesis in which we predicted that electronic aids assisted teaching contributes the elimination of negative attitudes to

school subjects, namely the subject physics. It was proved that the use of the multimedia teaching product *Principles of Geometry Optics* (either at school within the multimedia assisted teaching of the selected topics belonging to higher secondary school geometry optics curricula or at home within a self study as a supporting illustration study material), we designed for the purpose of the research, had a positive influence on the learners' answers in the particular post-test questionnaire items. Due to the use of the multimedia materials in teaching process the degree of the students' negative attitude to the subject physics significantly decreased in all the observed aspects, which were

- popularity of physics among the students,
- physics content attractiveness for the students,
- difficulty of learning physics for the students,
- comprehensibility of physics teacher explanation for the students,
- assessment of physics importance for everyday life and one's education in the students' opinion.

Although it was proved that the use of multimedia teaching materials contributes the elimination of students'negative attitudes to school subjects, also the fact was detected that a single use of teaching materials of this type is not enough to reach such result. The research results show a significant difference in the level of the achieved changes of students' attitudes. This difference is depending on the group the students belonged to. As the differences occured also between the two groups where the multimedia teaching materials assisted teaching was carried out, but in each of them based on electronic teaching aids of different level of interactivity and consequently, of course, different methodology of their use, it is clear that not any way of the use of multimedia materials in teaching process has an automatical impact on students. The impact depends on the interactivity level and mainly on the application of hands-on activities.

In connection to physics a very negative finding is that students do not see any relevant possibilities to apply and use knowledge learnt within this school subject in their everyday life. That is why they have a very low internal motivation to learning physics and the main motivation for them to learn it is their effort to gain a good mark also in this compulsory subject.

The created teaching materials *Principles of Geometry Optics* were presented and discussed at several international conferences and competitions in Slovakia and abroad, too. It was very rewarding to learn that these materials were highly assessed by the experts in the field and that they won the first place in the category *Assistance materials for on-line education* at the international competition of educational projects *E-learning in practice*, which was a part of the 5th international conference ICETA 2007 devoted to new e-learning technologies and their applications organised by the Technical University in Košice (Stará Lesná, 5. – 8. 9. 2007). Although the materials were created for the special purpose of our research, they can be used to assist teaching process in general, without any specific oriented purpose of their utilization in teaching process.

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Elektroninės mokomosios medžiagos poveikis ugdymo procesui: eksperimento rezultatai

Ján ZÁHOREC, Alena HAŠKOVÁ, Michal MUNK

Šiame straipsnyje autoriai nagrinėja el. mokomosios medžiagos kūrimo ir taikymo sunkumus mokant gamtos mokslo disciplinų. Taip pat nagrinėjama šios pagalbinės priemonės įtaka ugdymo kokybei. Pateikti tyrimo rezultatai buvo gauti atlikus tyrimą. Dėmesys buvo sutelktas ties galimybe įtakoti mokinių nuostatas ir požiūrį į konkrečius mokomuosius dalykus, daugiausia nemėgstamiausius. Apibūdinant dar tiksliau, buvo nagrinėjamos galimybės pakeisti mokinių neigiamą požiūrį į fizikos dalyką. Tikslinę grupę sudarė 17–19 metų amžiaus mokiniai. Siekiant pakeisti šios grupės požiūrį į fizikos dalyką, buvo sukurta įvairialypė mokomoji medžiaga ir interaktyvūs animuoti filmukai, pavyzdžiui, geometrinės optikos principai, apimantys pagrindines geometrinės optikos temas.