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Energy and its Transformation – Primary School Project Based Education Using Integrated E-learning

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Abstract

This paper presents the results of a pedagogical research into the applicability of the new education strategy - Integrated e Learning (INTe-L) - and its implementation into project-based education. The research was conducted on the subject of Physics and the participants were in 9th grades of two Slovak primary schools. INTe-L is based on the utilisation of experiments (real, remote and virtual) and educational e-materials in the acquisition of the natural science knowledge, as well as the possibility of using scientific methods in the above-mentioned process. Pedagogical research into the topic "Energy and its transformation" showed, INTe-L is not only an appropriate motivational and interactive way of teaching Physics, but compared with traditional teaching, it also enables students to better understand real world features.

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1. Introduction

Nowadays, an equivalent to what was called natural philosophy or the origin of advanced sciences in the past is Physics (Feynman et al., 2000). According to Feynman et al. (Ibid. 2000), Physics is the fundamental and all-embracing science, which has a profound impact on all scientific development. It is commonly known that the performance of pupils and students in Physics is not at the desired level. This concerns particularly the application of knowledge in the real life problem solving, This fact was also confirmed by the results attained by the Slovak students (Koršňáková et al., 2010) in the international testing of the OECD PISA (Programme for International Student Assessment) study testing mathematical and reading literacy along with the literacy in natural sciences of the 15-year old primary school (PS) pupils. C. E. Wieman, a Nobel Prize Laureate in Physics, says that nowadays, the transformation of education in Physics is essential (Wieman, Perkins, 2005). It is necessary to change the approach to Physics by introducing new methods and styles into teaching via the real word problem solving (Wieman et al., 2008). We chose the topic of energy, since, in all its forms and as a quantity; energy is a focus of the contemporary technology and natural sciences and the key question of mankind. The reasons are obvious and related

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to the life on the Earth, and, above all, to the perspective of the life of mankind on the planet of Earth. Everyday activities and experimentation with “energy" are stimulating for the young pupils, giving them hours of enjoyment and a passion for discovering, cognition and understanding of the sustainable real world.

2. Project based education “Energy and its transformation” via Integrated e-Learning

Modern teaching approaches paying attention to real world problems and emphasizing the pupil's own exploratory quest for knowledge surely include project based teaching. From a historical perspective, it cannot be regarded as a novelty.

Although project based education is a proven form of teaching, the latest Information and Communication Technology (ICT) enables us to make the process more interesting, funny and more interactive for both pupils and teachers. We have in mind the hitherto practically unused real remote experiments via the Internet as well as the use of virtual experiments through interactive simulations - applets, known as haslets.

Schauer et al. (2009) and Ožvoldová (2006), define Integrated e Learning (INTe-L) as a new education strategy, which was developed with the intention to introduce ICT and experimenting into teaching process more extensively. It is based on the methods the sciences used for the cognition of the real world, – such as exploration, discovery, data collection, their processing and evaluation, comparison with the models, all with the support and the wide use of the latest ICT. The cornerstone of INTe-L strategy (Fig. 1) is experiment: a) computer aided laboratory experiment (so called hands on), as well as a real remote experiment on the Internet, b) interactive simulations as virtual experiments mediated via the Internet, and c) electronic teaching materials (Ožvoldová 2006, Schauer et al., 2009).

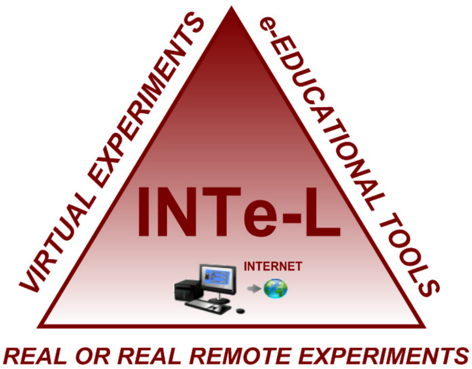

Figure 1 Project based education via Integrated e -Learning based on three constituent parts: real or remote experiments, virtual experiments and e-education tools (Ožvoldová, Gerhátová, 2010)

2.1. Pedagogical experiment

In the school years 2007/2008 and 2008/2009, we conducted a scientific research on the Physics lessons in the 9th grades of two Slovak primary schools (Gerhátová, 2009). In accordance with the goals of the knowledge society and concepts of the Slovak state education programs, the goal of the project was to elaborate and verify new methods of the natural sciences education in connection with the project-based teaching using tree components of the INTe-L strategy. The project was called *"Energy in Nature, Technology and Society"*. Following are the results of one of the six sub-projects: *"Energy and its transformation"*.

The research sample consisting of 155 pupils (85 pupils of experimental group, EG, and 70 pupils of reference group, RG) was selected on the basis of convenience sampling. We could not use a random sample of the target population (9th grade of Elementary school pupils in Slovakia) considering the time allowed for the sub-project (2 weeks) and the unwillingness of many teachers to cooperate. Before carrying out the pedagogical research, we conducted a pre-research on a small sample of 18 pupils of 9th grade of primary school in the school year 2006/2007 (Gerhátová, 2009). It focused on verifying the possibility of the INTe-L strategy application in project-based education, detection of potential drawbacks and determining whether the research strategies would work.

Prior to carrying out the pedagogical experiment, we gave the students a non-standardised didactic entrance test (pre-test) (Gerhátová, 2009) investigating the level of the pupils' pre-entry knowledge. This pre-entry knowledge (if very different in individual groups) might influence the results of the later post-tests. Since the number of test tasks did not exceed 20, we chose the weighted scoring method. The test consisted of 15 tasks requiring that the pupils use the knowledge gained in the lessons and knowledge from their everyday life, while making connections and searching for links. One task was a multiple choice, two tasks were open structured with the structure given conventionally and the remaining tasks were open questions and fill in the blanks. The maximum number of points in the pre-test was 35.

In order to find whether the variance in both data samples was approximately the same, we used the Fisher-Snedecor's F-test. The variance of the results in EG (Table 1) was 29.18 and 28.15 in the RG. The chosen level of significance $\alpha = 0.05$. Test criteria (Table 1) $F = 1.04$. Based on the attained results (Table 1) we can conclude that the critical value $F_{0.05}$ (84; 69) = 1.47 and the calculated value $F = 1.04$. We found that the calculated value F was lower than the critical value and that $P > 0.05$, and therefore we adopted the null hypothesis. We can thus conclude that there were no statistically significant differences in the variance in both groups and the application of Student's t-test with equal variances is therefore justified in this respect.

Table 1 Binomial F-test for Variance (EG, RG)

Statistical Variables	Pre-test		Post-test	
	EG	RG	RG	EG
Mean	11.96	11.29	9.21	10.72
Variance	29.18	28.15	6.63	5.63
Observation	85	70	70	85
Difference	84	69	69	84
F	1.04		1.18	
P (*F*<=f) (1)	0.44		0.24	
F crit (1)	1.47		1.46	

We tested the null hypothesis in the Student's t-test using the criteria t. The chosen level of significance $\alpha = 0.05$. We compared the calculated value t with the critical value of the test criteria for the chosen level of significance (Table 2) and the corresponding number of the degrees of freedom, in our case $f = 153$.

Table 2 Binomial t-test with Homogeneity of Variance (EG, RG)

Statistical Variables	Pre-test		Post-test	
	EG	RG	EG	RG
Mean	11.96	11.29	10.72	9.21
Variance	29.18	28.15	5.63	6.63
Observation	85	70	85	70
Common Variance	28.71		6.09	
Hyp. Difference of Means	0		0	
Difference	153		153	
t stat	0.79		3.78	
P(T<=t) (1)	0.22		0.0001	
t crit (1)	1.66		1.66	
P(T<=t) (2)	0.43		0.0002	
t crit (2)	1.98		1.98	

Based on the attained results (see Table 2) we can conclude that the critical value of Student's t-test for 153 degrees of freedom and the chosen level of significance is $t_{0.05}(153) = 1.98$. For the values shown in Table 2 $t = 0.79$. Since the calculated value t is smaller than the critical value and $P > 0.05$, we have to adopt a null hypothesis – "There are no statistically significant differences between the pretest results of EG and RG".

Prior to the actual execution of the project, the pupils were acquainted with its topic objectives, tasks and the method of assessing the project. Subsequently they were divided into teams of three. Since the teams had three members, each member was assigned two roles.

Furthermore, the pupils chose the procedure and gradually started working on the project, while implementing all the elements of the INTe-L strategy. The most frequently used forms of output were posters and PowerPoint presentations. After finishing the projects, individual groups of students gave presentation, which was followed by discussion and common evaluation of the projects, based on criteria given beforehand as a part of the project assignment.

At the same time, we taught the given topic to the RG in a traditional way, mainly using monological methods (description, explanation, narration), dialogical ones (dialogue, discussion), methods of working with textbooks, books, visual demonstration methods, methods of repetition and practising the knowledge, diagnostic and assessment methods. After conducting the pedagogical experiment, we gave the EG and RG a non-standardised didactic output test (post-test) (Gerhátová, 2009).

2.2. *The results of the pedagogical research*

Our main goal was to examine the influence of the project-based learning with the support of remote experiments on the pupils' scientific literacy development. The survey would be too detailed to include full results, so we give only the final results. (Complete statistical details have been reported elsewhere (Gerhátová, 2009).

The main results may be summarized as follows, given by the percentage of the correct responses:

a) In the pre-test: for EG – 34.2 % and for RG – 32.3 %,

b) In the post-test: for EG – 71.5 % and for RG – 61.4 %.

The achieved difference of 10 % for the experimental is encouraging for the continuation of both the project – oriented education and further implementation of INTe-L strategy into primary physics education.

As the number of test tasks in the individual interim tests did not exceed 20, we chose weighted scoring. The post-test consisted of 10 tasks - aimed at the reproduction of the acquired knowledge, but mainly on showing the knowledge of everyday life, linking and finding connections. Two were multiple-choice tasks, one task was sorting and 7 tasks were open-ended. The maximum number of points the pupils could get in the post-test was 15.

Fisher-Snedecor's F-test: In order to find whether the variance in both samples is approximately of the same size, we used the Fisher-Snedecor's F-test. The chosen level of significance $\alpha = 0.05$. The variance of the results in the EG (Table 1) is 5.63. The variance of the results in the RG (Table 1) is 6.63. The test criteria (Table 1) $F = 1.18$. Based on the results (Table 1) we can conclude that the critical value $F_{0.05}$ (69; 84) = 1.46 and the calculated value $F = 1.18$. We found that the calculated value F is lower than the critical value and that $P > 0.05$ and thus we adopted the null hypothesis, i.e. there are no statistically significant differences in the variance in both groups and the application of Student's t-test with equal variances is therefore justified in this respect.

We tested the null hypothesis in the Student's t-test using the criteria t. The chosen level of significance $\alpha = 0.05$. We compared the calculated value t with the critical value of the test criteria for the chosen level of significance and the corresponding number of the degrees of freedom, in our case $f = 153$. Based on the results (Table 2) we can conclude that the critical value of Student's t-test for 153 degrees of freedom and the chosen level of significance is $t_{0.05}(153) = 1.98$. For the values listed in Table 2 $t = 3.78$. As the calculated value t is higher than the critical value and $P < 0.05$, we have to reject the null hypothesis and adopt an alternative hypothesis "Between the post-test results of the EG in the cognitive area, in which the chosen topic was taught via project based teaching with the application of the INTe-L strategy, and the posttest results of the RG in the cognitive area, in which the pupils were taught traditionally, there is a statistical significance". The ten percent difference in the acquired physical knowledge regarding the energy can be considered as the benefit confirming the appropriateness of the learning strategies applied.

3. Conclusion

INTe-L as a new strategy of cognition of real world was successfully implemented into education process at the primary school physics education. Our pedagogical experiment justified the PhET team ideas "*The real experiments strongly support the examination of the real world. On the other hand, the virtual laboratories or simulations support an interactive approach, employ dynamic feedback, follow a constructivist approach, provide a creative workplace, make explicit otherwise inaccessible models or phenomena, and inspire students productively"* (Finkelstein et al., 2006).

The analysis and evaluation of the achieved results of the pupils participating in the pedagogical research conducted by us (Gerhátová, 2009) shows the appropriateness of introduction and wider implementation of project-based teaching supported by the INTe-L education strategy into the educational process in the 9th grades in two observed primary schools in the Slovak Republic with the topic *"Energy and its transformation"*. Another author (Žovínová, 2011, Ožvoldová, 2012, Kostelníková 2012) conducted research with another project in the 7th grade with similar results. We can conclude that project-based education via integrated e Learning prepares students for the 21st century challenges.

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