EDUCATION OF TEACHERS IN ICT APPLICATIONS FOR TEACHING PHYSICS AT PRIMARY AND SECONDARY SCHOOLS

Renata Holubova, Veronika Kainzova, Jan Řiha, Ivo Vyšin
Palacky University Olomouc, Czech Republic
E-mail: renata.holubova@upol.cz; kainzova@email.cz;
riha@prfnw.upol.cz; vysini@prfnw.upol.cz

Abstract

The aim of the paper is to discuss the results of the research in the field of using multimedia , ICT, in teaching and learning Physics in the Czech Republic. The first part of the project was realized in 2005, where the analysis of available multimedia resources and their use at schools was done. Evaluation criteria for multimedia materials were summarized. According to the findings in the second part of the project courses for physics teachers in using ICT were created. Basic tools for computer measurements (data processing, procedure management), basic tools for modelling and simulations (including internet tools); work in a virtual laboratory, especially in applets/physlets, work in a distant laboratory, ability to use it effectively, and knowledge of appropriate freeware, shareware and software were presented. There were for example courses: Interactive Physics in teaching physics, Mathematica and Mathematica CalcCenter in teaching physics, Digital phototechniques in laboratories and technical subjects, The word processor, LaTeX for teachers of sciences. The project was evaluated, results of the reliability and validity of the courses will be discussed.
Key words: *physics teaching, multimedia, ICT, computer measurements.*

Introduction

The methodology of teaching and learning Physics in the Czech Republic has to answer a key question: „How to teach physics“ in the new conditions of the System of Education in the Czech Republic. Since 2005 new school programmes are tested and it is necessary to define new competences for undergraduate Physics teachers and science students. A new way of teaching subjects is prefered – subjects are devided into groups with similar kontext (Man and nature), interdisciplinary realtions are pointed out. The kea question i show to improve the duality of teaching and learning and how to motivate a recruit more science students. The one way is to motivate students by doing amusement Physics with a lot of simple hands free experiments. On the other hand the knowledge in science, technology and technique rises enormous. The question is how to transform the knowledge into the school physics. The students are using various technology devises and equipment but the technical backgroud they didn´t know and understand. The mostly out of date equipment in school laboratories cannot take concern in class experiments . One way how to overcome of this problem is to use multimedia in teaching and learning physics. Maybe that teaching with multimedia, e-learning , virtual classrooms, multimedia based laboratories help us to do Physics more interesting for students and make possible to present up-to-date science in the classroom.

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The ideas to teach Physics with computers is not new and we can find lot of papers and conference proposals about PC applications in Physics teaching (Holubova, 2004d). There were various lines to use PC:

- desplay subject matter
- practice subject matter
- solve problems
- studying with individual rate
- using multimedia elements – videos of demonstrations.

Teaching with multimedia

In the last few years the number of computers at schools has dramatically increased.

The real situation is diverse from school to school. In a great number of schools computers are used only in mathematics and computer science. Teachers at our schools can be devided into three groups:

1. The first one refuses teaching with multimedia. The main teaching aid is a piece of chalk and the blackboard.
2. In the second group there are teachers who can use multimedia and computers but they are not able to develop their own software.
3. In the third group there are teachers interested in new teaching trends, they develop software, create new programmes, multimedia textbooks, physlets.

The development of the technology makes it possible to use the computer in various ways in the course of teaching and learning. New research in the theory of learning opened ways for understanding the advantages and disadvantages of PC based teaching and learning technologies.

In the first part of our research the situation at secondary and high schools was analyzed. Findings according the questionaire and interviews can be summarized.

Benefits of computer based teaching

Computer based teaching and learning has a lot of benefits. The number of teachers who are able to use computers in their classroom has inreased and they find new and new ways for emerging technologies. Some trends in teaching access are pointed out(Holubová 2004:

- a shift from whole-class to small group instruction
- a shift from lecture and recitation to coaching
- a shift from working with better students to working with weaker students
- a shift toward more engaged students
- a shift from assessment based on test performance to assessment based on products, progress, and effort
- a shift from competitive to a cooperative social structure
- a shift from all students learning the same thing to differnect students learning different things
- a shift from the primacy of verbal thinking to the integration of visual and verbal thinking.

The experiences in using multimedia materials can be summarised as follow:

- using multimedia during reading of lessons – Java applets, animations, video sequences make clear some difficulties with explanation of problems and phenomena, that cannot be shown inmediatelly in the classroom

- taking advantage of on-line books, articles and other materials for solving problems
- using multimedia by doing homework (- individual students path to solution)
- better graphic presentation
- computer based experimental sets in the physics laboratory

Imperfections of computer based teaching

Teaching Physics with multimedia is now common at secundary schools, high schools so as at the university. Teachning with multimedia is one posibility how to increase the level of knowledge in Physics and science. From the other point of view we have to ask another question: how much multimedia, PC, virtual labs is profitable not to get lost the physics background ?

- Materials presented via multimedia: textbooks – for some students are boring, they need a written textbook for their study and an oral comunication with the teacher. The real experiment and the word of the teacher is irreplaceable for them. A good MM textbook must be interactive, helps in understanding the material presented during the lecture. But an inevitable part of teaching physics are demonstrations – they make a connection between the theory and the application of physics and they are very important. That´s why it is necessary to find the right way between the classical way of teaching with real experiments and the new one using multimedia.
- Virtual experiments are only plane experiments.
- MM teaching programmes are expensive.

Internet in the classroom

The Internet is today a wide spread learning tool. You can find here information in the text form, audio or video clips, java applets, physlets and many others. You can make connection with people all over the world. The students using the Internet develop their skills in analyzing data, evaluating information that they need for the life in our society. The basic problem is now the increasing number of Internet sites. Internet as the subway of informations is sometimes mentioned as the most effective way for using PC in teaching and learning. But the great number of presented www sites brings an other problem – not all the software is good quality, some pages are out of date, sometimes the addresses get lost. The teacher by searchig the Interent has to ask and answer a lot of questions:

…Is the software of high technical quality, are the materials current, is the language clear, are the materials evaluated, can I use the software inmediatelly with high efficiency in my lesson, are the instrustions clear, can the student be creative, is it a freeware (shareware) and others…

The amount of resources and the problems concerning the Internet searching led to activities of creating evaluation criteria for physics web sites and some organisations of voluntiers were established. One of these organisations is the group MPTL (Multimedia in Physics Teaching and Learning). Evaluation criteria were summarized and important searching nets working under the head of large universities were presented. The number of criteria is now about 60. An other activity is the EUPEN (European Physics Education Network) with about 123 partners.

List of most important evaluation criteria (EPS group):

Motivation:

- user – friendliness (is it easy to start using the MM?, is the function of control element evident? Are the software requirements clear and of adequate proportion?)
- attractiveness (Is the layout appealing?, Is there a motivation introduction?, Are there interactive components?, Is the topic interesting (reference to everyday life, applications, explaining a phenomenon)?)
- Clear description of purpose and work assignment (Is the intention of the MM evident?, Does the user know what is expercted from him?, Is there a problem to solve or a context to understand?)

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Content:

- Relevance (Is the topic important?, Does it make sense to use MM (dynamic process)?)
- Scope
- Correctness (Is the content of the MM correct?, Are the simplifications indicated?)

Method:

- Flexibility (Is the MM appropriate for a broad target group?, Is it possible to use the MM in different teaching and learning situations?, Does the MM allow for the same topic to be approached in different ways?)
- Matching to target group(Is a reasonable didactical reduscton implemented?, Are the technical terms explained?)
- Realization (Is the general approach suitable to present the subject and realize aims of the MM?, Is the type of MM chosen reasonable (video, simulation, animation)?)
- Documentation (Is the operation obvious or explained?, Is the material self evident or explained by additional text?, Is there a reference to material for further studies?, Ae any suggestions for implementation into the teaching process?)

According to these criteria the searching machine Fyzweb (http://fyzweb.cuni.cz/index.php) was recomended for teachers in the Czech Republic.

Important findings of our research

The real situation at our schools - the teachers are not prepared for the work with MM (the pupils are better with handling the PC then they teachers), time stress at schools.

On the other hand in some cases explanation of problems with PC is the only way of visualisation. In a lot of cases the PC seems to be cheaper then an experimental set. An increasing number of young people are PC invalid subordinated and the only way for studying is with help of the computer.

An increasing number of web-based teaching a learning materials and techniques are presented. MBLs are commercially developed and consits of an interface system and a collection of sensors and the needed software. The best known system is ISES (http://www.ises.info/index.php/en/ises). ISES – Intelligent School Experimental System is wide spread in the Czech Republic and can be used at secundary schools so as at universities. Experiments realised with this computer based laboratory set are on various levels. They are easy to operate. Manuals and results of experiments can be found on the web. The system is evaluated and makes it possible to do live and real physical experiments controlled and measured via Internet. The first on-line experiments are installed in Prague, at the Department of Physics Education, Charles University.

Internet is today an integral part of science education. To take full advantage of these huge amount of resources and activity abilities will take a long time. Not only the student but also the teacher must learn, how to work with this device. Information presented on the Internet are easy availeble, it is not necessary to use only printed materials. The informations are topical, modern, a printed textbook cannot contain the last discoveries and knowledge. And the greatest advantage of the Internet is the contact with students, researchers, teachers all over the world.

Findings from the first part of the project – it is necessary to improve the quality of pre-service and in-service teacher education in ICT application.

The project Education of teachers in ICT applications

Project "*Education of Teachers in ICT Applications for Teaching Physics at Primary and Secondary Schools*" took place in the time period June 2006 – June 2008. The project was aimed at improving the quality of the study programs of the Physics teacher training by means of using

information and communication technologies (ICT) in Physics teaching. The target group comprised the current students being trained to be Physics teachers as well as those interested in further studies, including the lifelong education courses for Physics teachers, and graduates of specialized university programs who are interested in gaining further education in Physics teaching. The main aim of the project was to innovate the study programs of teaching Physics at the Faculty of Science, the Palacky University, and to create new courses of further education for Physics teachers with the use of ICT. The project also included the construction of a modern classroom and a laboratory to be used by teachers who learn to use ICT in Physics teaching as well as by all the target groups. Materials to be used in the educational courses for all the target groups have also been purchased. In the classroom there are 12 computers, all with a fast internet connection, which enable students to learn about a number of possibilities of working with ICT in Physics classes. These possibilities include basic tools for computer measurements (data processing, procedure management), understanding their principles, capabilities, as well as their limits; basic tools for modeling and simulations (including internet tools); work in a virtual laboratory, especially in applets/physlets, understanding their capabilities and constraints; work in a distant laboratory, ability to use it effectively, to understand its capabilities and limits; and knowledge of the appropriate freeware, shareware and software purchased within the framework of the project. The outcomes of the project can further be used in educating students who are trained to become Physics teachers in the area of ICT, e.g. how to teach Physics students and other subjects to use the mathematical software. The classroom can also be used during events organized for secondary-school students and others who are interested in the study of Physics. These events include Olympiads in Physics, competitions, seminars and presentations for secondary-school teachers and students.

Students of the courses have become acquainted with the software "Interactive Physics". This software makes it possible to model, simulate and investigate the whole spectrum of physical phenomena. Almost all the experiments can be modeled by using the mouse only. The courses took place in the newly-constructed computer classroom. Every participant had a personal computer the "Interactive Physics" program installed. They were also acquainted with main possibilities of the software and the program setup. Then the participant were assigned specific exercises (problems) which they were solving with the help of the software and tutor's help. The closing part of the lesson was devoted to other software features (downloading of created models from internet, tutors questions etc.). The course participants have also filled out the feednback forms concerning the quality level of these courses. This evaluation is presented in the second part of this paper.

Another part of the project comprised the application of the *Mathematica* and *Mathematica CalcCenter* programs in Physics education, particularly in solving physical problems (exercises) at the secondary-school level. *Mathematica CalcCenter* is presented as a simplified, financially more available version of the *Mathematica* software. In contrast to *Mathematica*, which is typically approached to as a net programming language (where it is necessary to know the syntax of the commands), *Mathematica CalcCenter* enables performing the operations in a transcendental way. A user can simply set all requisite operations just with the help of the templates and a computer mouse. *Mathematica CalcCenter* is far more favorable (user's friendly) for users who do not work regularly with programs or software of similar kind.

Both programs enable to solve the entire series of the mathematical operations such as basic mathematical operations and basic functions, algebraic operations, working with vectors and nuts, fluxional and integral calculus, solving algebraic quadratics and systems of algebraic quadratics, solving fluxional quadratics, statistical and other functions, up to the graphic functions. Hence, they are applicable for solving physical exercises at the secondary-school level with a considerable margin.

The above-mentioned programs were used for solving the problems themselves (set by the project) as well as for the graphic presentation of the results obtained. The graphic representation of the results as such or the ones dependent on the parameters set by the problems/exercises facilitates a better notion of the solution to a given problem. The solution to a series of exercises has been worked out, such as, for example, the solution and subsequent graphic illustration of the electrostatic multipoles in electric fields, calculations of conductors in magnetic fields, solving the Bohr's atom hydrogen model, selected exercises of mechanics (for example, free falls in defined environments,

projection at an angle etc .) or calculation and illustration of the complex amplitude and the light intensity in Fraunhofer's flexural phenomenon.

The course participants have been acquainted with the possibilities of the use of the experiment that was connected to a computer in teaching of Physics. Within the project, the following facilities have been purchased:

- USB Oscilloscope DSO 2100
- a video camera Sony DCR-SR190E a digital camera Olympus SP-510 UltraZoom
- the component of the ULAB system IP Coach that includes measurement in the following sections:
    - electricity (4 analog entrances will enable the measurement of basic elements characteristics)
    - mechanics (2 electronic dynamometers will help in experiments with a great accuracy)
    - thermodynamics (part of the set is thermocouple makes it possible to measure he temperature dependence until 1300 degrees of Celsius)
    - magnetism (exact sensitive element will enable to measure the stationary magnetic field, e.g. permanent magnet or cops)

All of IP Coach outputs are viewable on a computer screen, processable and eventually printable. We are extending the possibilities of the inclusion of experiments with the computer support to the Physics education by means of a video and digital camera which are available in most of the schools.

The course participants have also been acquainted with the various applets and physlets which are available for the Physics education at elementary and high schools. For example:

- www.aldebaran.cz here you can find an applet that was created by the FEL CVUT students as a supplement to the Physics and Astrophysics education,
- surendranath.tripod.com/Applets.html Java applets form different parts of Physics,
- Applets on webpages of the Charles Univerzity in Prague, Faculty of Mathematics and Physics:
    - fyzweb.cuni.cz/piskac/cmain.htm
    - fyzweb.cuni.cz/piskac/pokusy/fen03/cindex.htm
    - fyzweb.mff.cuni.cz/dilna/index.htm#aplety
    - A wide applet database can also be found on the webpage of the high school in Vysoké Mýto:
    - www.gvmyto.cz/internetkouba/_private/Prehledappletu.htm
    - phet.colorado.edu/web-pages/index.html Interesting applets from University of Colorado

Evaluation

A discussion of the participants on the incorporation of the different applets into the Physics lessons was also part of the seminars (tutorials). The realized courses have also been evaluated by means of the feedback forms handed out at the end of each lesson. The course participants were to give their answer to, among others, these questions:

1. Did you have to study at home as well to pass the course? (Fig. 1)
2. Was the course contributive to your pedagogical practice? (Fig. 2)
3. Were you satisfied with the work of the training center? (Fig. 3)
4. Were the course materials of a good quality? (Fig. 4)
5. Did you participate in the course voluntarily? (Fig. 5)
6. Has the tutor proved a good level of his/her expertise? (Fig. 6)

7. Was the tutor's lecture intelligible? (Fig. 7)
8. What skills should be developed in the area of the ICT application in Physics education? (Fig. 8)

Each of the questions (1 – 8) provided the following answer choices:

a. I entirely agree
b. I agree
c. I don't know
d. I beg to differ
e. I beg to differ entirely

These graphs show the evaluation of the course „Mathematica CalcCenter for teachers"

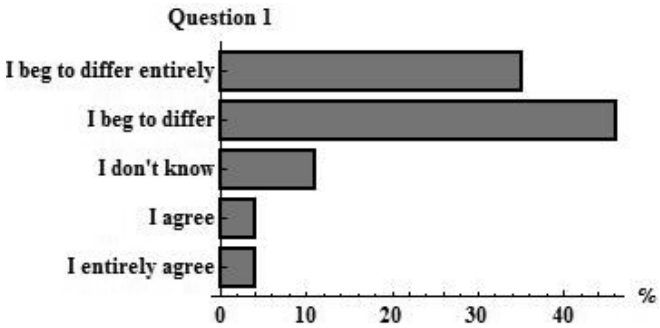

Figure 1. Did you have to study at home as well to pass the course?

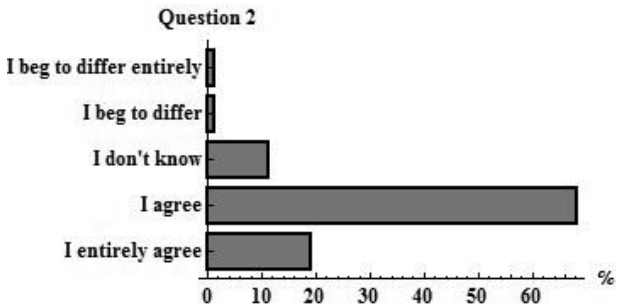

Figure 2. Was the course contributive to your pedagogical practice?

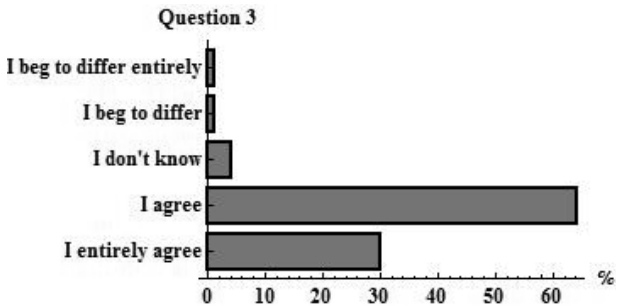

Figure 3. Were you satisfied with the work of the training center?

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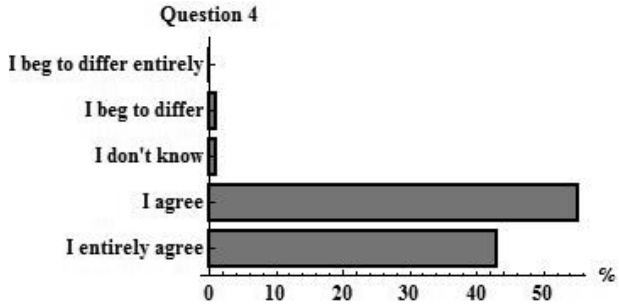

Figure 4. Were the course materials of a good quality?

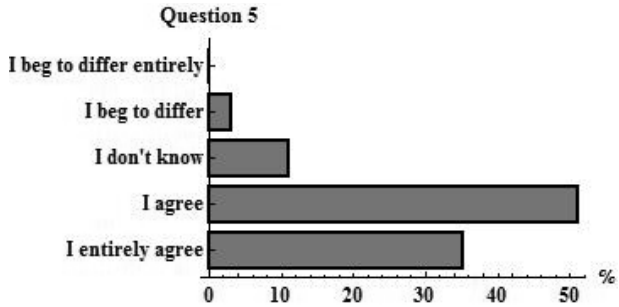

Figure 5. Did you participate in the course voluntarily?

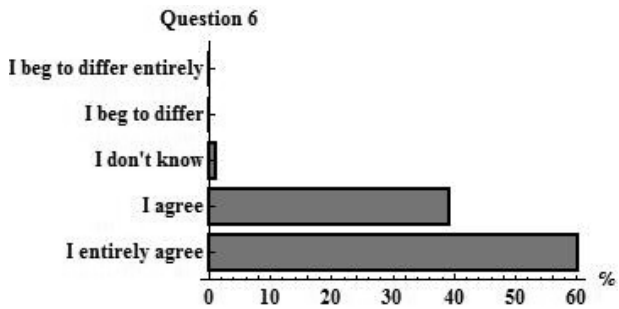

Figure 6. Has the tutor proved a good level of his/her expertise?

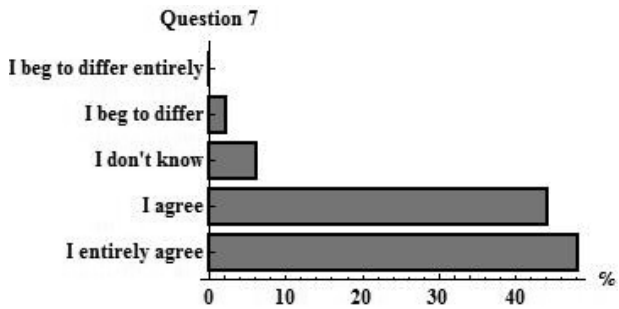

Figure 7. Was the tutor's lecture intelligible?

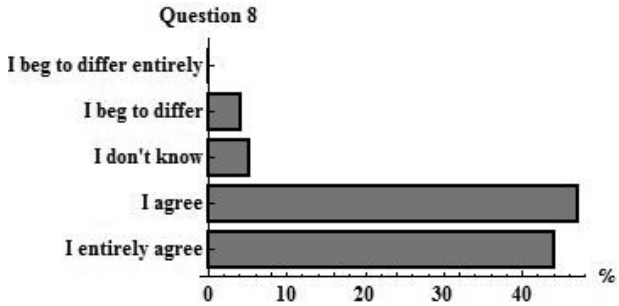

Figure 8. What skills should be developed in the area of the ICT application in Physics education?

Conclusions

From the graphic evaluation of each of the questions can be seen that using the ICT facilities is positively accepted not only by teachers but also (primarily) by their students.

Evaluation of the project „Education of teachers in ICT applications for teaching Physics at primary and secondary schools" showed that using the ICT facilities in Physics teaching is a very useful instructional agent in the modern time of tutorial technology, by means of which we can find some new possibilities in the teaching of Physics. The use of ICT facilities is most contributive and helpful in the domains where it is impossible to demonstrate the real experiment (e.g. in astronomy) or where there are no appropriate tools available, or, possibly, the use of the real facilities/tools is not safe with regard to the pupils age etc. We know that the ICT technology cannot replace the real experiment. The aim of this project was not the replacement of the real experiment by the ICT facilities, but finding new alternatives in Physics teaching. We will be searching for new ways in this field, especially in the model-experiment connection and the comparison of these two elements.

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Adviced by Roman Kubinek,
Palacky University, Czech Republic

Renata Holubova Assistant professor at Palacky University (Faculty of Science, Department of Experimental Physics), Olomouc, Czech Republic
17. listopadu 50, 771 46 Olomouc, Czech Republic
E-mail: renata.holubova@upol.cz
Website: http://exfyz.upol.cz/didaktika

Veronika Kainzova Doctoral student at Palacky University, Olomouc, Czech Republic
17. listopadu 50, 771 46 Olomouc, Czech Republic
E-mail: kainzova@email.cz
Website: http://exfyz.upol.cz/didaktika

Jan Řiha Assistant professor at Palacky University (Faculty of Science, Department of Experimental Physics), Olomouc, Czech Republic
17. listopadu 50, 771 46 Olomouc, Czech Republic
E-mail: riha@prfnw.upol.cz
Website: http://exfyz.upol.cz/didaktika

Ivo Vyšin Assistant professor at Palacky University (Faculty of Science, Department of Optics), Olomouc, Czech Republic.
17. listopadu 50, 771 46 Olomouc, Czech Republic
E-mail: vysini@prfnw.upol.cz
Website: http://optics.upol.cz/