

# PROCEEDINGS

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of the Union of Scientists - Ruse

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Book 5  
**Mathematics, Informatics and  
Physics**

Volume 7, 2010



RUSE

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**SERIES 5**

**"MATHEMATICS,  
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PHYSICS"**

**VOLUME 7**

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## REMOTE EXPERIMENTS – NEW APPROACHES TO PHYSICAL EXPERIMENTATION

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**Abstract:** *The computers and the Internet have become powerful tools for teaching and learning physics at all levels of science education. This paper presents the remotely controlled physical experiment that is located at the Department of Experimental Physics at Palacky University in Olomouc and which is available free on-line on the website <http://www.ictphysics.upol.cz/remotelab/>. A remote experiment is a real experiment with real laboratory instruments and equipment that can be controlled by a teacher or a student or another user from their computer via the Internet.*

**Keywords:** *experiment, remote experiment, ICT.*

### INTRODUCTION

A way how to motivate students in physics teaching and learning is to use Information and Communication Technologies (ICT) in physics lessons. It seems to be necessary to combine traditional and simple experiments with multimedia. ICT provide a wide range of possibilities in teaching physics. We can demonstrate that science can be fun and understandable. Some surveys in the Czech Republic (e.g. [7]) show that physics is negatively evaluated by students in primary and secondary schools. In contrast ICT is one of the most popular subjects. Nowadays, the use of ICT in physics lessons is most beneficial. In many cases is indispensable using a computer in conducting and measuring physical experiments.

### THE ROLE OF EXPERIMENTS IN TEACHING PHYSICS

Carry out experiments is a necessary part of teaching physics and helps students to understand the essential natural phenomena and the principles related to the subject. Physics is a science based on experiences, observations and experimentally found facts. Theoretical ideas are important, but only if their consequences can be verified by observations or experiments [4].

We can divide the physical experiments into three basic categories.

The first category of physical experiment includes real, classical experiments conducted in the traditional school laboratories. The role of practical work is even more relevant of these days that are characteristic of rapid changes in technology and society. Classical laboratory works are a traditional part of teaching physics. Students are usually divided into small groups of 2 students. The activities are concentrated to achieve skills in the measurement of basic physical quantities and define the accuracy of the measurement, manipulation with simple equipment, tools and measurement instruments. The main parts of skills that the students have to achieve are competences for cooperation, making predictions and conclusions and doing a laboratory report.

Some problems of classical laboratory work will be mentioned:

- Not sufficient equipment, out of date instruments.
- Large group of students (only one works the others are passive).
- Computer simulation instead of real experiments (in a number of situation, the computer is cheaper than the experimental set).
- Inadequate teacher instruction.
- The teacher is not motivated in doing labs with their students.
- Small number of practical lessons in educational programmes.

- A great part of students do not see the meaning of the work.
- Low degree of freedom – a cook-book for doing the lab work.

The second group consists of virtual experiments conducted in virtual laboratories. Students do not work with real laboratory tools in these laboratories, they only control virtual objects. The physical virtual experiment takes form of the JAVA applets. Many new physical flash applets are arising on the websites which are usually available free to any user. In these virtual laboratories a number of attractive and dangerous physical experiments may be created that are not possible to accomplish in real school laboratories. A specific problem is the application and use of the internet in physics teaching and learning. There can be found a huge number of simple animations, simulations, java applets and physlets on the World Wide Web. For a great number of teachers it is easier to use these animations than prepare a real experiment.

The third category represents the real experiments that can be on-line controlled by users through the Internet. A remote experiment is used as a nomenclature for these types of experiments. A remotely controlled experiment consists of two conceptually distinct parts. First of all, there is the experiment itself, which is connected to a computer with a remote access. Secondly, there is a method used to provide the necessary remote features. The experiment is controlled via software through the internet by issuing commands to an interactive surface [8]. The possible schema of such a remote experiment is illustrated in Fig. 1.

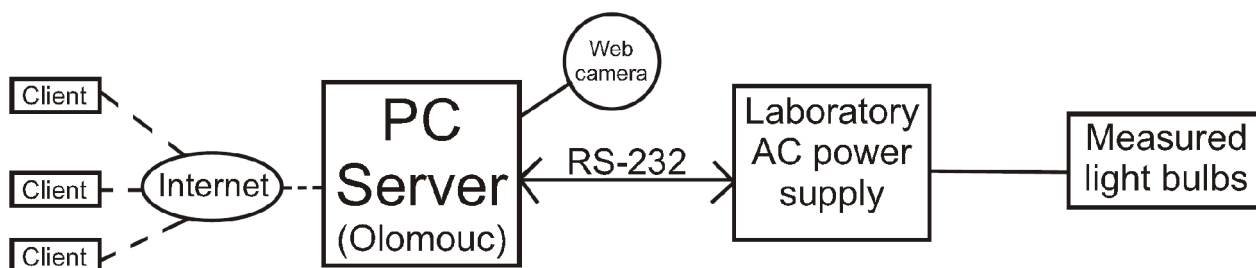


Fig.1. Block schema of our remotely controlled experiment

### ADVANTAGES AND DISADVANTAGES OF REMOTE EXPERIMENTS

Remote control has been used for many years in research, including large particle accelerators, space science, and telescopes, and in technology development, including robotics, manufacturing processes, and control [1]. Remote control has applications not only in industrial areas but also in science education. Remotely controlled experiments have several benefits different from simulations in virtual laboratories and from classical experiments in the traditional school laboratories. The main advantages of remotely controlled laboratories are [6]:

- The students can carry out experiments from anywhere in the world at anytime (24 hours, 7 days per week) and they are not limited by physical lessons.
- The remote experiments are always assembled and they are permanently ready for measurement of physical quantities.
- Unlike virtual simulations, remote experiments provide real-time experiments with real laboratory instruments and equipments.
- Some experiments have unique results for the particular place of measurement (e.g. the calculation of gravitational acceleration  $g$  from oscillations of a

mathematical pendulum). After performing the real experiment in a physics lesson at school, students can carry out their own experiments from remotely controlled laboratories via the Internet as their home assignment.

The main disadvantages of remotely controlled laboratories are:

- Working in the classical school laboratories provides a direct contact with real measure equipment and offers an immediate feedback of the teacher or the classmates, what is very difficult possible in the remotely controlled laboratories.
- In the traditional laboratories students gain practical skills during the preparation of individual experiments.

### DEVELOPMENT OF OUR REMOTE EXPERIMENT

The remote experiment at Department of Experimental Physics, Palacky University in Olomouc is available free (without registration, 24 hours and 7 days a week) on the web address <http://ictphysics.upol.cz/remotelab>. We have chosen an important experiment from the field of experimental physics to demonstrate the functionality and ability of remotely controlled experiment to train our students to become teachers of physics. This experiment can be controlled by another user from their computer via the Internet.

Our remote control experiment consists of laboratory AC power supply. This power supply is equipped with the interface RS232 and it is possible to control the power supply from a personal computer. Other instruments are two digital multimeters and six different light bulbs (e.g. incandescent, energy saving, LED, halogen light bulb, etc.).

The Fig. 2 depicts development of our remotely controlled experiment. The first we had a remote experiment with one incandescent light bulb (A), then we created remote experiment with compare between incandescent and energy-saving light bulbs. Nowadays, we have remote experiment with comparison among six light bulbs (C).

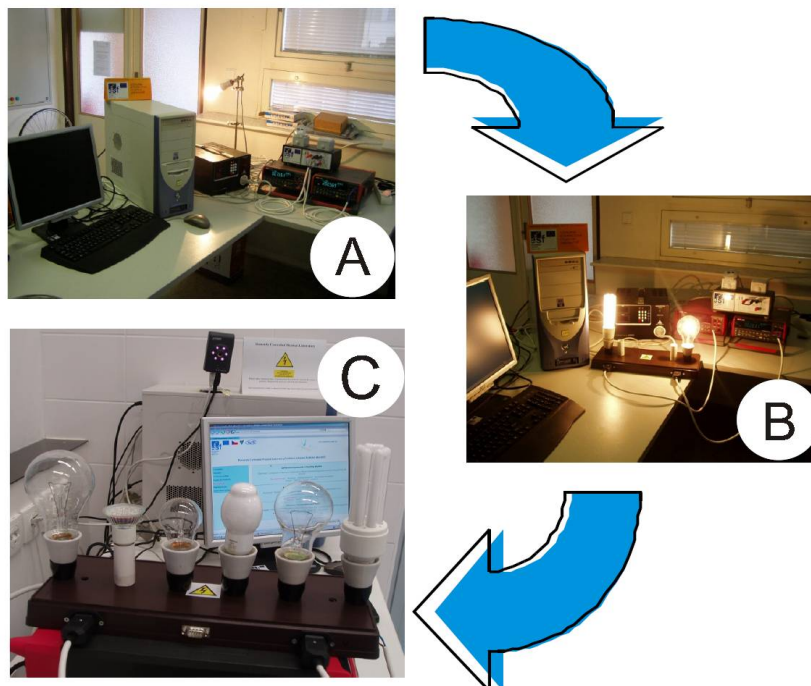


Fig.2. Development of our remote experiment

On the web address <http://ictphysics.upol.cz/remotelab> is created a special control interface of our remote experiment. This control interface allows users with a personal computer to remotely control an experiment from a separate location. An experimenter needs the ordinary web browser (Mozilla, Opera, Internet Explorer, etc.) as well as the Java SE Runtime Environment (JRE) tool installed to his/her computer only. Then the voltage of up to 250 V has to be set and the actual measured electric current flowing through different light bulbs is displayed. The actual measured values of voltage and current are recorded in volt-ampere characteristic. This experiment can be not only controlled and measured, but obtained data can be transferred to application (Word, Excel, etc.). The on-line events occurring in our laboratory are shown by the real time video image. We prepare to add into this experiment some new measured equipment (thermometer and luxmeter) for measuring the temperature and lighting of light bulbs.

### **OTHER REMOTELY CONTROLLED EXPERIMENTS IN THE WORLD**

Research and development of remote laboratories can be divided into two major conceptions. The first method how to create and control remote laboratories is use of industrial measurement system LabVIEW from National Instruments. LabVIEW is a graphical programming environment used by millions of engineers and scientists to develop sophisticated measurement, test, and control systems using intuitive graphical icons and wires that resemble a flowchart [9]. This technique is very suitable for users who want to create a remote experiment. The main disadvantage LabVIEW is the expensive purchase price of measuring ADDA card, which must be purchased from National Instruments. The control of these experiments through Internet is extremely complicated for ordinary users, teachers or students, because the experimenters needs the special and very large software NI LabVIEW Run-time Engine installed to his/her computer. Use of LabVIEW is not appropriate for teaching physics at school.

The second method how to create and control remote laboratories is create of own measurement system or use of measurement system, which does not require an additional installation of the large software. In this case, an experimenter needs the standard web browser (Mozilla, Opera, Internet Explorer, etc.) as well as the Java SE Runtime Environment (JRE) tool installed to his/her computer only. This method, without complicated installation large special software into computer is appropriate for teaching physics at school.

Nowadays, one of the best remotely controlled laboratory is created at Charles University in Prague in the Czech Republic. On the web address <http://www.ises.info/> [10] are free available physical remote experiments (e.g. Electromagnetic induction, Diffraction on micro objects, Heisenberg uncertainty principle, etc.).

Other well-designed remote experiments are created at University of Technology Kaiserslautern in Germany. On the web address <http://rcl.physik.uni-kl.de/> [11] are on-line accessible physical remote experiments (e.g. Millikan's experiment, Examine voltage-current characteristics of semiconductor devices, Photoelectrical effect, etc.).

### **CONCLUSION**

There are some possibilities how to improve the interest in physics and science education and how to develop competences for a successful outcome into the practical life. The school environment must be changed – the leading role of the teacher in physics education must be changed to the role of a discussion manager and an organiser of students' activities. The school education has to come closer to students practical life and this can be done only by improving the ways of students own activities. Only then will be the student prepared for the life in the changing society. The students must be able to

decisions, to solve problems, to be creative. The competences in knowledge and handling skills must be interdisciplinary. This can be achieved only in an active school environment with laboratory work, experiments, field work and projects.

The experiment in physics teaching and learning is the most important medium and teaching subject. From this point of view the experiment has a basic didactic and methodological function and students have to recognize the importance of experiments in science. The development of various types of experiments can be seen in the history of teaching physics. Nowadays several types of experiments are used in physics teaching and learning: classical experiments, hands on simple experiments, low-cost high-tech experiments and microcomputer – based experiments.

In physics teaching and learning there can be used various types of experiments. It depends on the teacher and the school environment, which type of experiment is realized. The experiment has a central position in physics education. It is the only way to develop students handling skills, communication and cooperation competences that we need for the life in our society. From this point of view a crucial role in the use of ICT will have the remote experiments.

The use of a remote experiment is most beneficial and helpful in the domains where it is impossible to demonstrate the real experiment or where there is no appropriate equipment available. Our aim is not the replacement of the real experiment by the remote experiment but finding new alternatives in teaching science. Nowadays, we have just one experiment which is controlled through the Internet from web address <http://www.ictphysics.upol.cz/remotelab/>. One of our main goals is to make a number of functional remote experiments which will be available free on-line through the Internet (24 hours, 7 days a week) for teaching and learning physics from anywhere in the world.

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## ЕКСПЕРИМЕНТИ ОТ РАЗСТОЯНИЕ – НОВИ ПОДХОДИ В ЕКСПЕРИМЕНТИТЕ ПО ФИЗИКА

**Франтишек Латал, Рената Холубова**

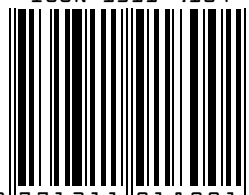
*Университет в Оломоук, Чехска република*

**Резюме:** Компютрите и Интернет са изключително полезни за преподаване и изучаване на физика на всички нива на обучение. Предлаганата работа представя експеримент от разстояние, който е разработен в катедрата по Експериментална физика към Университета в Оломоук и е на свободен достъп он-лайн на адрес <http://www.ictphysics.upol.cz/remotelab/>. Този експеримент е реален експеримент, с реални лабораторни уреди, който може да бъде контролиран от преподавателя, студента или друг потребител чрез компютър посредством Интернет.

**Ключови думи:** експеримент, експеримент от разстояние, ICT – технология.



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