REMOTELY CONTROLLED EXPERIMENT: COMPARISON OF VOLT-AMPERE CHARACTERISTICS BETWEEN INCANDESCENT AND ENERGY SAVING LIGHT BULB

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Abstract

The paper deals with the remotely controlled physical experiment which is located at the Department of Experimental Physics at Palacky University in Olomouc. A remote experiment is a real experiment with real laboratory instruments and equipment that can be controlled by a teacher or a student or any user from their computer through the Internet. The article presents our first remote experiment (comparison of volt-ampere characteristics between incandescent light bulb and energy saving light bulb with using AC) which is available free on-line on the website http://www.ictphysics.upol.cz/remotelab/. This paper outlines our current research and reflection of remotely controlled experiments and it describes the educational point of view of the remotely controlled system.

Key words: *remotely controlled experiment, remote experiment, information and communication technologies, incandescent light bulb and energy saving light bulb.*

Introduction

Conducting experiments is a necessary part of teaching physics at all levels of science education and helps students to understand the basic natural phenomena and the principles related to the subject. As the information and communication technologies evolve, the concept of performing experiments in science education changes as well. The world around us is changing and we must change our approach to physical experimentation at school.

We can divide the physical experiments into three fundamental groups (Lustig, 2007).

• The first group consists of real experiments conducted in the traditional school laboratories. 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. Students gain practical skills during the preparation and measurement of individual experiments in these traditional laboratories.

• The second category of physical experiment comprises 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 (e.g. the simulations of the processes in the universe or the simulations of extremely minute particles in the area of molecular physics). Nowadays, the best ones of well-designed virtual simulations are created at University

of Colorado within PhET project (Wieman et al., 2008).

• The third group represents the real experiments that can be on-line controlled by users via the Internet. A remotely controlled experiment or in short a remote experiment is used as a nomenclature for these kinds of experiments. These remote experiments can be particularly advantageous in science education where experimental procedures are too dangerous. The remotely controlled experiments consist of two conceptually different parts (Thomsen et al., 2005). First of all, there is the real 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 remote laboratory conception requires technical, pedagogical and computer science competencies. Due to these requirements, it appears to be more complex than other e-learning contexts such as on-line courses, virtual classrooms and e-project (Benmohamed et al., 2004). The possible schema of such a remote experiment is illustrated in Figure 1.

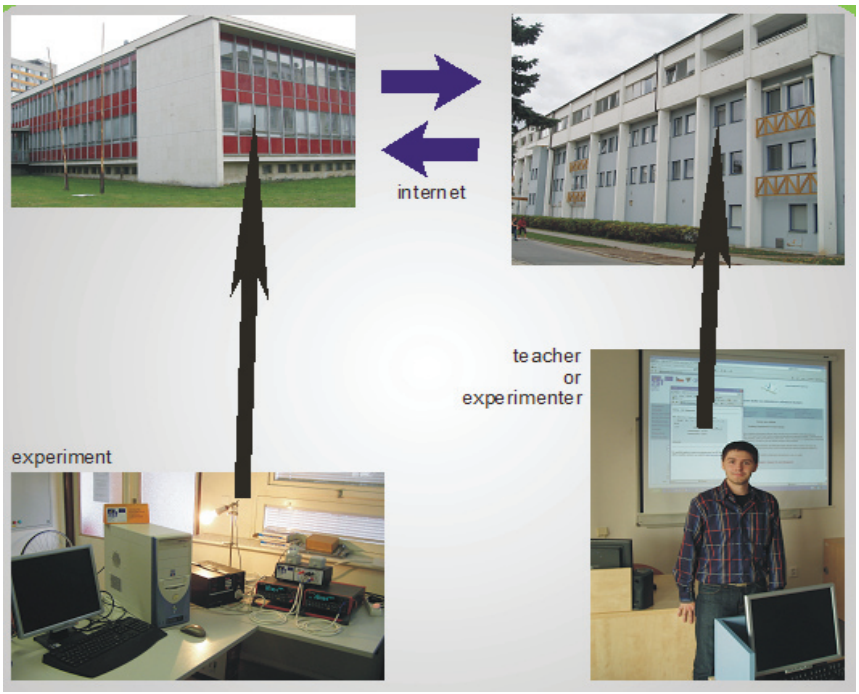

Figure 1. Typical schema of remotely controlled experiment. Remote experiment (left) takes places in a location separate from the teacher or experimenter (right).

Advantages of Remotely Controlled Experiments

The remote experiments are suitable for an international exchange at the university level of education in all its forms (lecture, laboratory, exercises and self study) (Ožvoldová et al., 2005). Remotely controlled experiments have several benefits different from simulations in virtual laboratories and from classical experiments in the traditional school laboratories.

• The students can carry out experiments from anywhere in the world at anytime (24 hours, 7 days a 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.

• Remote experiments are necessary to perform time-consuming experiments, which take

several days, for collaborative experiments between distant learners, for experiments requiring expensive laboratory instruments and equipment that are usually not available to students, and for dangerous experimental procedures (Lee et al., 2002).

• 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 number of households connected to the Internet is increasing in member states of the European Union (see Figure 2).

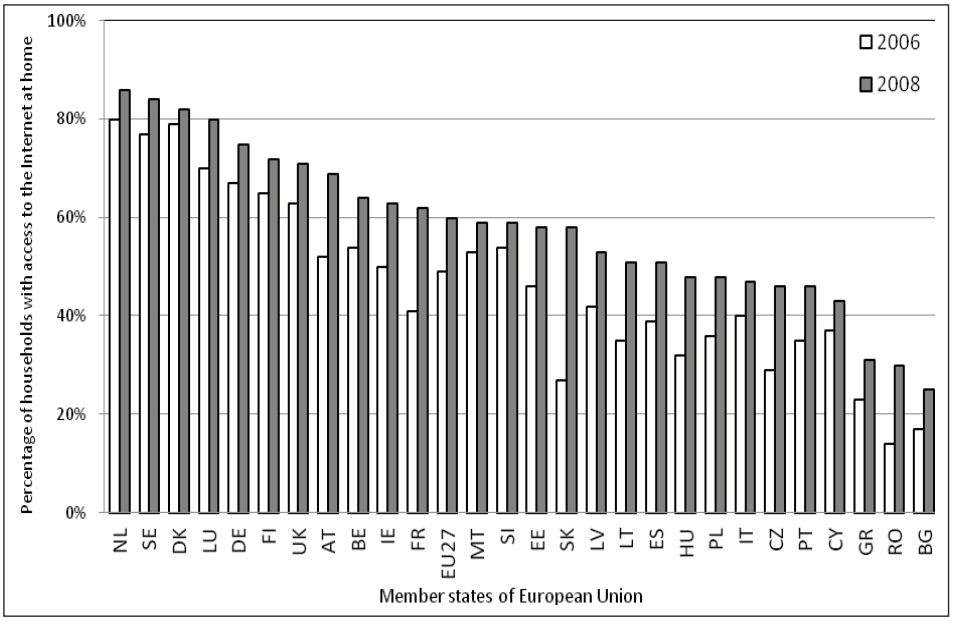

Figure 2. **Percentage of households having access to the Internet at home in member states of European Union in 2006 (white bars) and in 2008 (grey bars), (Eurostat, 2009).**

Remote experiments have advantageous applications not only in science education system but also in industrial areas. There are some benefits of industrial use of remote experiments (Auer, 2001):

• Expensive and complex instruments can be used from different locations of a company.

• Team members, working at different locations can take advantage of the same test-run results without extra travelling.

• Long-term trials (reliability, failure, performance) can be comfortably supervised from home, e.g. at weekends.

Our Remotely Controlled Experiments

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. Our first experiment, the comparison of volt-ampere characteristics between incandescent light bulb and energy saving light bulb with using AC, is measured remotely.

This experiment consists of laboratory AC power supply DIAMETRAL AC250K1D. 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 precision digital multimeters UNI-T UT805

with calibration, incandescent light bulb NARVA 230V/200W and energy saving light bulb Philips Master 33W/827. This simple electric circuit is connected to a computer with remote access.

Our remotely controlled experiment is available free (without registration, 24 hours and 7 days a week) on the web address http://www.ictphysics.upol.cz/remotelab/. There is a lot of information about this experiment (e.g. introduction, physical background, experimental arrangement, pictures and statistics). Most data is written in Czech language but some information is translated into the English as well as the Lithuanian languages.

Special software was developed to control the experiment remotely via the Internet. The control interface of our experiment (which is completely translated into the Czech, English and Lithuanian languages) is illustrated in Figure 3. This control interface allows users with a personal computer to remotely control an experiment from a separate location. An experimenter needs the ordinary INTERNET EXPLORER browser 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 an energy saving and incandescent light bulb is displayed. The actual measured values of voltage and current are recorded in volt-ampere characteristic for incandescent light bulb and energy saving light bulb. The on-line events occurring in our laboratory are shown by the real time video image.

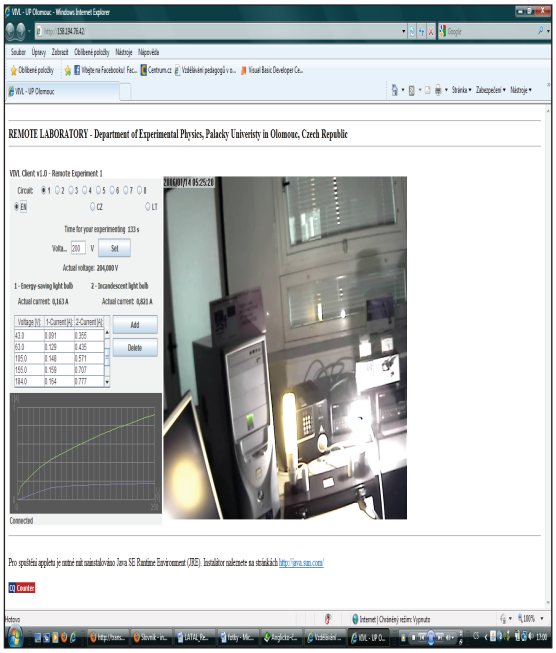

Figure 3. Control interface of our remotely controlled experiment.

An access to a remote laboratory and its use during physics lessons provides the teacher with the possibility to change a common physics lesson and to make it more interesting for students, who are not very motivated to science studies today. Furthermore, our experiment represents a typical situation that is too dangerous for in-class demonstration. The measurement of volt-ampere characteristics of voltage of up to 250 V is not allowed at schools in the Czech Republic (Říha et al., 2008).

The importance of comparative volt-ampere characteristics between incandescent light bulb and energy saving light bulb is increased in accordance with the regulation of European Commission No. 244/2009. This regulation says that all member states of European Union must phase out incandescent light bulbs from September 2009 to September 2012.

The Table 1 depicts the number of users who visited our website with our remote experi-

ment between 1st May and 31st August 2009. A unique visit is defined as one individual visiting our website once per hour. The unique visitor has unique attributes: IP address, browser and operation system. A reload visit is the total number of visitors who have clicked the "Refresh" or "Reload" buttons within 60 minutes from the first time they viewed a page on our Internet site. We observe many visits from the Czech Republic but there are also visitors from foreign countries (e.g. Lithuania).

Table 1. The number of users who visited our website with our remote experiment between 1st May and 31st August 2009.

Month	Unique	Reload	Total
May	62	45	107
June	21	14	35
July	59	70	129
August	127	113	240
Total	269	242	511

Conclusions

Remotely controlled experiments have become a widespread tool for teaching physics at the university level of education. 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. We will be searching new ways in this field.

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 via the Internet (24 hours, 7 days a week) for teaching and learning physics from anywhere in the world.

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