

REMOTE TEACHING LABORATORIES IN PHYSICS LESSONS - ATTITUDES OF STUDENTS AND TEACHERS TO THE REMOTELY CONTROLLED EXPERIMENTS

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Abstract

This article describes five remotely controlled experiments, which were created at the Department of Experimental Physics in Olomouc (Volt-ampere characteristics of six different light sources, Determination of gravity from the period of oscillation of the mathematical pendulum, Study of water flow in the system of closed tubes, Weather station at Palacky University in Olomouc and Monitoring of radioactive background in Olomouc). These experiments are accessible from the web address <http://ictphysics.upol.cz/remotelab>. The paper describes a new approach to creating remotely controlled experiments using Web Services from the company National Instrumnets.

The paper also deals with questionnaire survey, which examined attitudes of students and teachers to the remotely controlled experiments. This questionnaire survey was attended by 74 students of Physics from Faculty of Science in Olomouc and 48 teachers of Physics from secondary schools. 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: ICT, internet, physics, questionnaire, remotely controlled experiment.

Introduction

The gigantic expansion of the Internet has a gigantic effect on the physics education. 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 physics studies today. *Educators must have an open attitude and that they should sensibly incorporate technological development, because otherwise they may risk teaching the students of today how to solve the problems of tomorrow with the tools from yesterday* (Dormido, 2002).

The web based remote control laboratory is a system that enables users (students or teachers) control of real experiment from a remote location using internet and an ordinary web browser. By contrast to virtual laboratories (in the virtual laboratory students do not work with real laboratory tools, they only control virtual objects), remote control labs consist of 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 purpose of remotely controlled labs is to allow users with a computer to remote control an experiment from a separate location (24 hours a day, every day of the year). *The reasons why remotely controlled experiments are used include the lack of equipment at the local institution, cost, insufficient time for data collection or too much data and danger to the experimenter* (Gröber, 2008).

This article describes a questionnaire survey, which examined attitudes of students and

teachers to the remotely controlled experiments. This questionnaire was given in January 2011 and was attended by 74 students of Physics from Faculty of Science in Olomouc and 48 teachers of Physics from secondary schools. The questionnaire contained 13 questions. It examined, how often used real experiment, virtual experiment and remotely controlled experiment are in real Physics lessons in secondary schools. Approximately after 6 months was again examined how have changed attitudes of teachers of Physics to the remotely controlled experiments.

Description of Five Remotely Controlled Experiments

Over the past three years, was created five remotely controlled experiments at the Department of Experimental Physics in Olomouc in the Czech Republic. All the remote experiments are placed on the website <http://ictphysics.upol.cz/remotelab> and are freely available 24 hours a day.

The first experiment “*Volt-ampere characteristics of six different light sources*” consists of laboratory AC power supply. The 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.). In Figure 1 is a website with this remote experiment. In the left part of the website is an online image from two webcams. One camera shows all view of the laboratory with experiment and the second webcam shows the power factor in AC circuits. In the right part of the website is the control panel of the experiment. In this control panel the users can enter voltage in the range 1 to 250 volts and measure the current in the circuit for the selected light source.

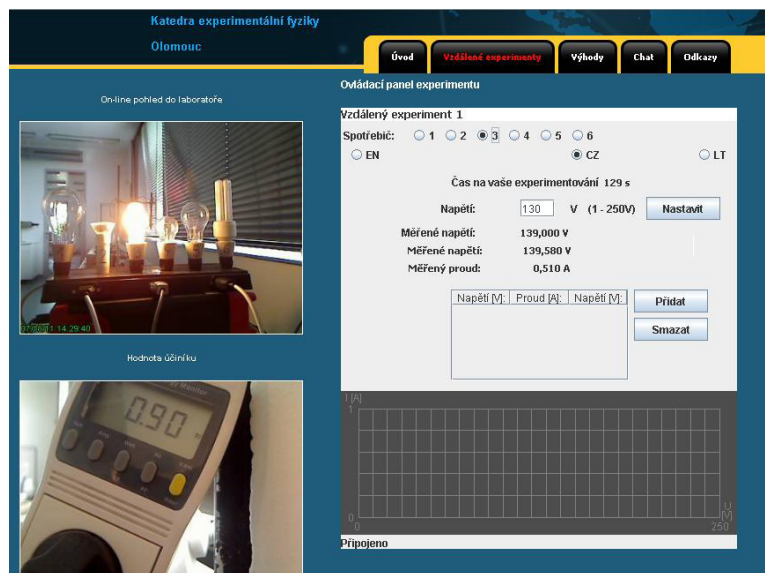


Figure 1: Web page with the first remote control experiment.

The second experiment “*Determination of gravity from the period of oscillation of the mathematical pendulum*” consists of Internet School Experimental System - ISES (control board ISES PROFESSIONAL, modules: an optical sensor and relays, measuring ADDA card) and software ISES WEB Control. Other parts of this experiment are: microprocessor control, actuator motor, electromagnet, mathematical pendulum and two stabilized power supplies (see Figure 2).

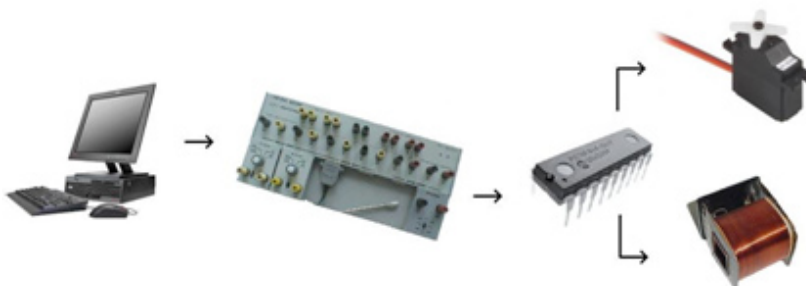


Figure 2: Parts of the second remote experiment.

The other remote control experiments “*Weather station at Palacky University in Olomouc*” and “*Monitoring of radioactive background in Olomouc*” was made in July and August 2011. In these experiments users can watch online changes of pressure, temperature, humidity, lighting, and radioactivity in our laboratory in Olomouc. In this case, it is not a traditional “remote control experiment”, but the type of “remote sensing experiment”. The user does not change the measurement conditions, but only records the measured data from a remote location. Measurements are nonstop. Data from start of measurement can be downloaded and processed.

Last remotely controlled experiment is “*Study of water flow in the system of closed tubes*”. This experiment is being prepared and will be operational as soon as possible. This remotely controlled experiment is unique in the Czech Republic for several reasons. First, in the Czech Republic is no remote experiment, which deals with study of fluid flow in tubes. Secondly, in the Czech Republic is not remotely controlled experiment that would use sensors made by Vernier and software LabVIEW from the company National Instruments. This last remote control experiment is composed of two flow rate Vernier sensors, three Vernier barometers, one USB Vernier thermometer probe, two interfaces Vernier SensorDAQ, DC circulation pump and closed system of transparent tubes filled with water.

The software LabVIEW includes functions with *Remote Panels technology*, which allows access program developed through a web browser. This approach has one major disadvantage. Each client computer must have installed the special program LabVIEW Run-Time Engine, which has size approximately 120 MB. In the high school is often a problem installing a new program on school computer. In 2010, National Instruments introduced its new web service called “Web Services” (see Figure 3). Web Services work as a web application programming interfaces. Running web service runs by entering the URL address that defines which program to run and passes the value of the input terminals.

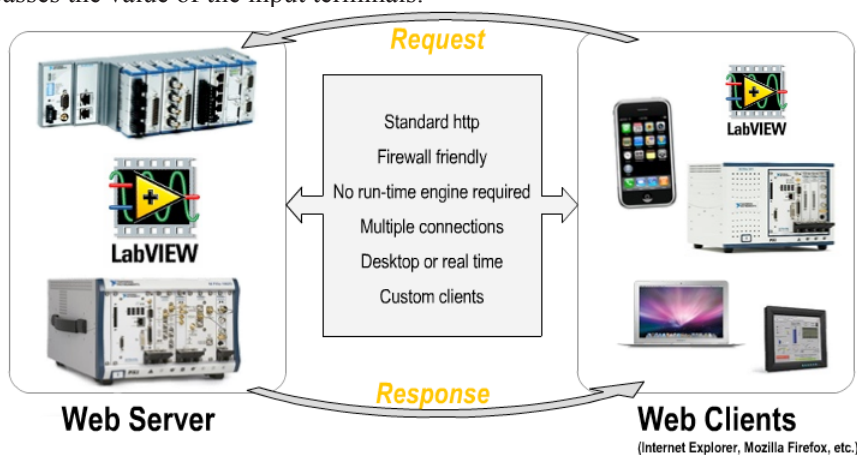


Figure 3: Web Services from National Instruments. (Kepř, 2011).

Attitudes of Students and Teachers to the Remotely Controlled Experiments

In January 2011 was conducted a questionnaire survey. The first three questions surveyed, how often are used real experiment, virtual experiment and remotely controlled experiment in real Physics lessons in secondary schools. In these questions was used Likert scale (Answer 1 = NEVER, Answer 6 = EACH LESSON). The answers to these questions are shown in Figure 4, 5 and 6.

- **Question 1** (for teachers of Physics from secondary school): How often do real experiments in teaching physics?
- **Question 1** (for students of Physics from Faculty of Science): How often did real experiments your teacher of Physics in secondary school?

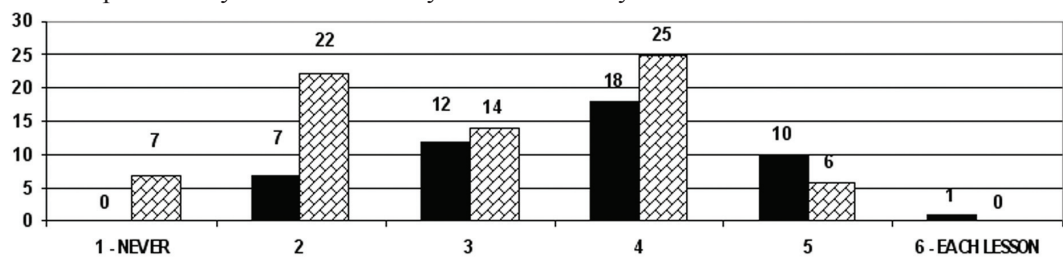


Figure 4: Question 1 – Answers of teachers (black bars), answers of students (white bars).

In these survey results, option 4 is the most frequent response of teachers and students too. Median from answers of teachers is option 4 and median from answers of students is option 3.

- **Question 2** (for teachers of Physics from secondary school): How often do virtual experiments (java applets) in teaching physics?
- **Question 2** (for students of Physics from Faculty of Science): How often did virtual experiments (java applets) your teacher of Physics in secondary school?

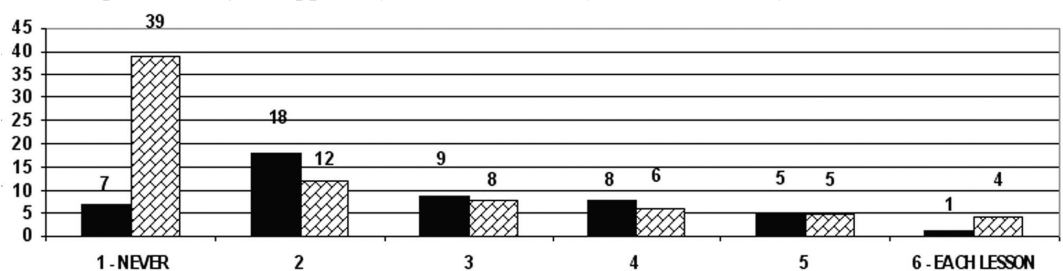


Figure 5: Question 2 – Answers of teachers (black bars), answers of students (white bars).

In these survey results, option 2 is the most frequent response of teachers and option 1 (NEVER) is the most frequent response of students. Median from answers of teachers is option 2 and median from answers of students is option 1. Teachers of Physics make more real experiments than virtual (java applets) experiments.

- **Question 3** (for teachers of Physics from secondary school): How often do remote control experiments (via internet) in teaching physics?
- **Question 3** (for students of Physics from Faculty of Science): How often did remote control experiments (via internet) your teacher of Physics in secondary school?

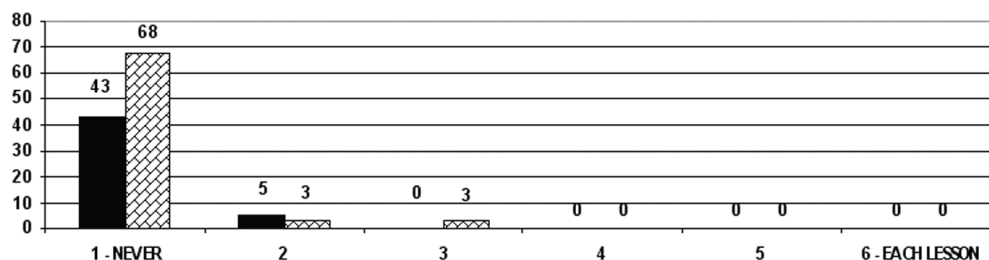


Figure 6: Question 3 – Answers of teachers (black bars), answers of students (white bars).

In these survey results, option 1 (NEVER) is the most frequent response of teachers and students too. In January 2011, teachers did not use remote physics experiments in his/her Physics lessons. Teachers and students obtained instruction (together with the questionnaire, in paper form) how to work and control our first remotely controlled experiment “*Volt-ampere characteristics of six different light sources*”. After testing the remote measurements at our website (<http://ictphysics.upol.cz/remotelab>) respondents could complete the second part of the questionnaire. In the second part of the questionnaire was for example a question:

- **Question 6** (for students and teachers): What is your overall evaluation (based on your own experience) this kind of experiment? (Answer 1 = DEFINITELY POSITIVE, Answer 6 = DEFINITELY NEGATIVE)

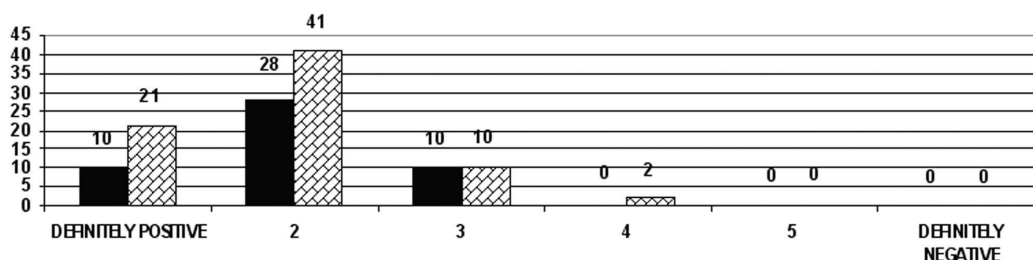


Figure 7: Question 6 – Answers of teachers (black bars), answers of students (white bars).

In these survey results, option 2 is the most frequent response of teachers and students too. Median from answers of teachers is option 2 and median from answers of students is option 2 too. The graph showed that teachers or students who are familiar with this type of experiments, then these experiments evaluated positively.

Approximately after 6 months was again examined how have changed attitudes of teachers of Physics to the remotely controlled experiments. In June 2011 was conducted the second questionnaire survey. This questionnaire was attended by 23 teachers of Physics from secondary schools. The survey contained only one question:

- **Question 3B:** How many times have you used remotely (via Internet) controlled experiments in your physics lessons (during the last half year)?

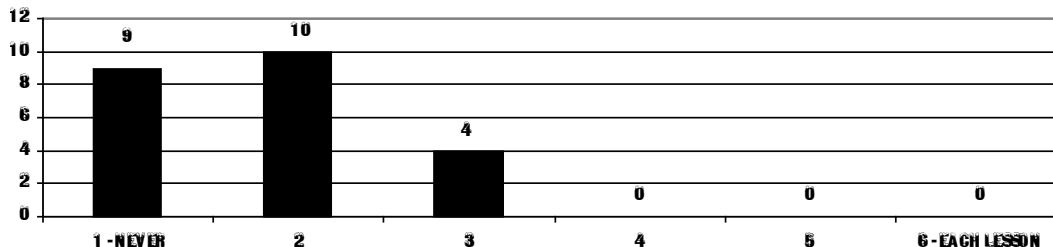


Figure 8: Question 3B – Answers of teachers (black bars).

In these survey results, option 2 is the most frequent response of teachers and median is option 2. Compared with question 3 we see that the approximately 60 % of teachers used the remote controlled experiment in your lessons of Physics at least once. In question number 3 responded approximately 90 % of teachers that did not use the experiment ever in your lessons of Physics.

Conclusions

The traditional face to face school classrooms are changing in modern virtual or remote control laboratories. This paper describes five remotely controlled experiments, which were created at the Department of Experimental Physics in Olomouc. Our aim is not of course the replacement of the traditional face to face experiments by the remotely controlled experiments but finding new alternatives in teaching of experimental physics.

The survey showed that physics teachers from secondary schools (from the Czech Republic) more commonly used real experiment than virtual experiments. Remotely controlled experiments are not currently used in teaching physics in secondary school. In the survey respond approximately 90 % of teachers of secondary school that did not use the experiment ever in your lessons of Physics.

Many scientific articles describing remotely controlled experiments, but the functional experiments, which are used in real teaching is not much. In the Czech Republic are approximately 15 remote experiments which can be used in teaching physics at secondary school (five experiments are at the Department of Experimental Physics in Olomouc). Teachers of secondary schools do not know that these experiments exist. In some school laboratories are not computers with internet access or teachers do not want to change experimentation in their teaching.

Producers of remotely controlled experiments must also create guides and manuals for teachers to work with experiments. Were created guides and manuals, how to work with remotely controlled experiments. Teachers or students who are familiar with this type of experiments, then these experiments evaluated positively. 60% of teachers who have tutorials available for working with remote experiments conducted these experiments in their classes at least once during the half year. Students commonly use the latest equipment (iPad, iPhone) and some teachers have problems effectively use a computer with internet access in teaching physics. The world around us is changing and we must change our approach to physical experimentation at school.

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

References

Dormido, S. (2002). Control Learning: Present and Future. In: *Proc. 15th IFAC World Congress on Automatic Control*. Barcelona, Spain.

Gröber, S., Vetter, M., Eckert, B., Jodl, H. J. (2008). Remotely controlled laboratories: Aims, examples, and experience. *American Journal of Physics*, 76, 374-378.

Keprt, J. (2011). *Webové prostředí NI LabVIEW Web User Interface Builder. On-line seminář*. Retrieved from <http://zone.ni.com/wv/app/doc/p/id/wv-2745> (10/10/2011).

Látal, F. (2011). *Remotely controlled laboratory*. Retrieved from http://ictphysics.upol.cz/remotelab/index_en.html (05/10/2011).

Lustig, F. (2011). e-Laboratory project. Retrieved from <http://ises.info> (06/10/2011).

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