Experience with Remote Physics Experiments in Student's Laboratory

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Abstract — *The latest trend in experiments both in student's laboratories and lectures using e-learning in Physics and Nature sciences is the remote laboratory studio via Internet. The experience with remote interactive experiments in real teaching process in physics laboratory at the Faculty of Pedagogy in Trnava University is presented. The distant WEB experiments produced in the Faculty Mathematics and Physics, Charles University in Prague were run under software ISES WEB Control® package (consisting of WEB server, Image Server for the support of WEB cameras, Measure Server for the control of the hardware in our case ISES and HTTP Relay Server)[4]. The students with their computers were connected via a standard WEB browser Internet Explorer. The „laboratory exercise" was carried out in a common computer classroom equipped with standard PCs, the students were guided how to collect the remotely measured data and how to evaluate for the final results. For the remote experiments special written instructions for students were prepared, with physics background and leading ideas how to proceed. The results and analysis of the gained experience in this pedagogical experiment is discussed in detail.*

Index Terms — *e- learning, Internet laboratory studio, pedagogical experiment, remote experiments*

INTRODUCTION

Internet as a new cultural phenomenon enters in all levels of education, including university level. In recent years remarkable progress has been achieved in e-learning texts, collection of exercises, repetition materials and self choice tests, the reason being the substantial progress in both accessible hardware and networking. Also, the technique of presentation and programming software has made an enormous progress [1].

One, substantial part of the technical and science universities education in all technically oriented and science subjects are real experiments, examining qualitatively or quantitatively the real phenomena or real objects. The experiments form integral part of any form of education, both in lectures and exercises, and already Comenius stressed the necessity of integrity of all forms of perception of the subject matter by all senses during of the teaching process [2]. Surprisingly a little progress has been made in this direction, the reason being the high cost of both the hardware, software and teach ware and connected personal costs . Another reason appeared to be a historical one, the long time – established role of experimental laboratories and laboratory instructors with low susceptibility to deep reaching changes and introduction of new methods of schooling.

Real world experiments form an indisputable part of physics, as is the case in all science subjects, dealing with the real world phenomena. The absence of experiments in all forms of physics education, both qualitative and quantitative or at least references to them brings about the loss of motivation and of deep understanding of real world phenomena. This is the reason, in all prestige education institution the physics experiments play indispensable role in curricula, though for various reasons cut and under supported. One of the ways were the Internet may help are WEB removed laboratories [3].

To test the feasibility of the WEB removed laboratory was undertaken by three University institutions Charles University in Prague (hardware and software), Tomas Bata University in Zlin (teach ware and experiments design) and Trnava University in Trnava (pedagogical experiment), where the first remote interactive experiments in real teaching process in physics freshmen laboratory was carried out. The students were connected with their computers via a standard WEB browser Microsoft Internet Explorer. The distant WEB experiments were assembled in the Faculty Mathematics and Physics, Charles University in Prague.

This paper presents the results of the pedagogical experiment in Internet quantitative remote physics experiments, testing both the hardware and software [4] of the WEB experiments of **Mechanical oscillator** [5], **Electromagnetic induction** [6] and **Photovoltaic element** [7] and corresponding pedagogical teach ware within the framework used for the experiment. This experiment is oriented on extension of the e-learning teaching tool for the basic Physics course [8].

TECHNIQUES USED FOR EXPERIMENTS

The experiments were run under software ISES WEB Control® package [4] (consisting of WEB server, Image Server for the support of WEB cameras, Measure Server for the control of the hardware in our case ISES and HTTP Relay Server) and in one case simultaneously with LabVIEW environment .

As trial experiments Mechanical oscillator, Electromagnetic induction and Photovoltaic element were chosen, the first covered the mechanics, the second electromagnetic field with the meaningful picture information and the third addressed electronic circuits and energy transformation issues.

For the purpose of illustration, let us present the remote experiment of Mechanical oscillator (http://kdt-17.karlov.mff.cuni.cz/pruzina.htm), whose schematical diagram and corresponding WEB panel are in Figure 1 a and b, respectively. The experiment is suitable to study all essential properties of the mechanical oscillator, damped oscillations, forced oscillations including energy law of conservation and its transfer and resonance phenomena. The examples of the rough Internet data presentation are in Figure 2, the data after some rearrangement for graphical presentation are in Figure 3, and the the forced oscillation amplitude characteristics with the phenomenon of resonance are in Figure 4.
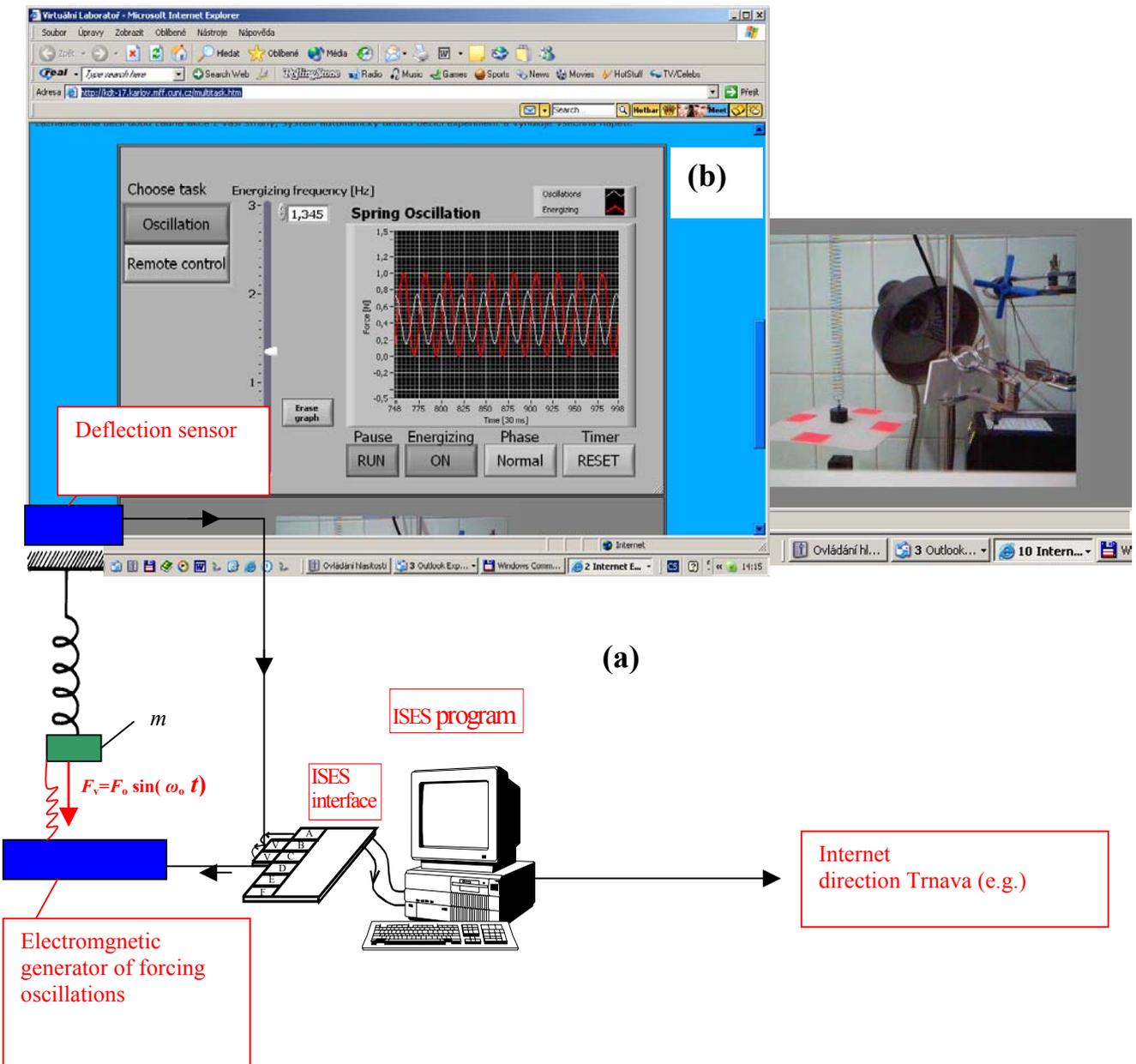

FIGURE 1
SCHEMATICAL DIAGRAM (a) AND WEB PANEL (b) OF THE EXPERIMENT MECHANICAL OSCILLATOR
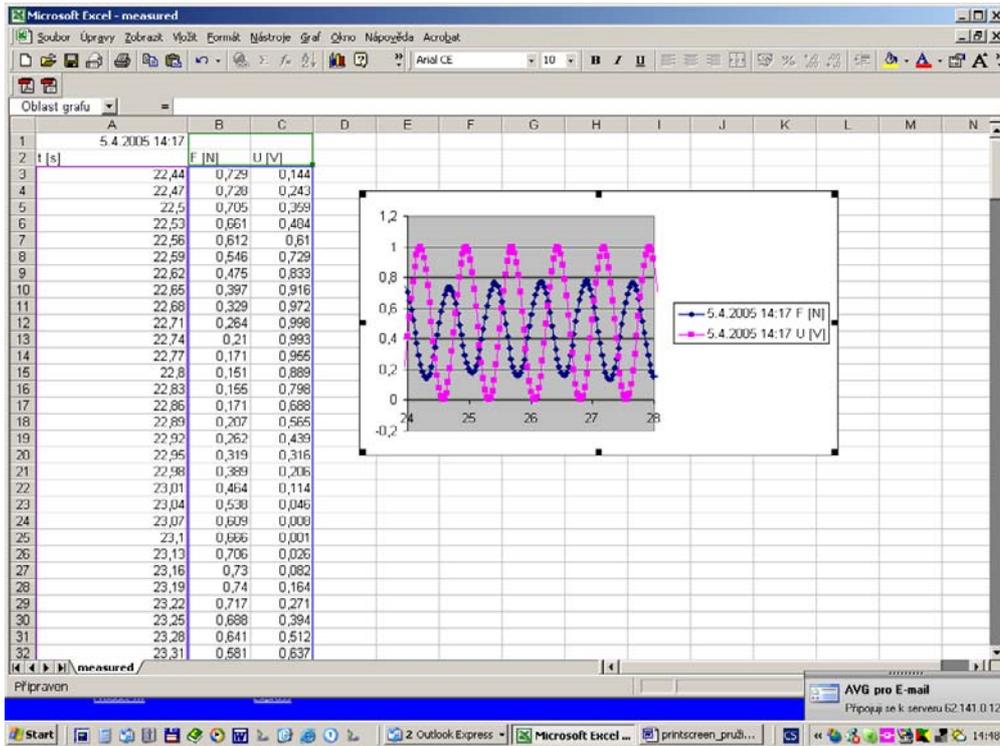 (http://kdt-17.karlov.mff.cuni.cz/pruzina.htm)

FIGURE 2
EXAMPLES OF THE INTERNET TRANSFERRED DATA TO THE STUDENTS COMPUTER AND THEIR GRAPHICAL REPRESENTATION USING EXCELL 2000 ENVIRONMENT
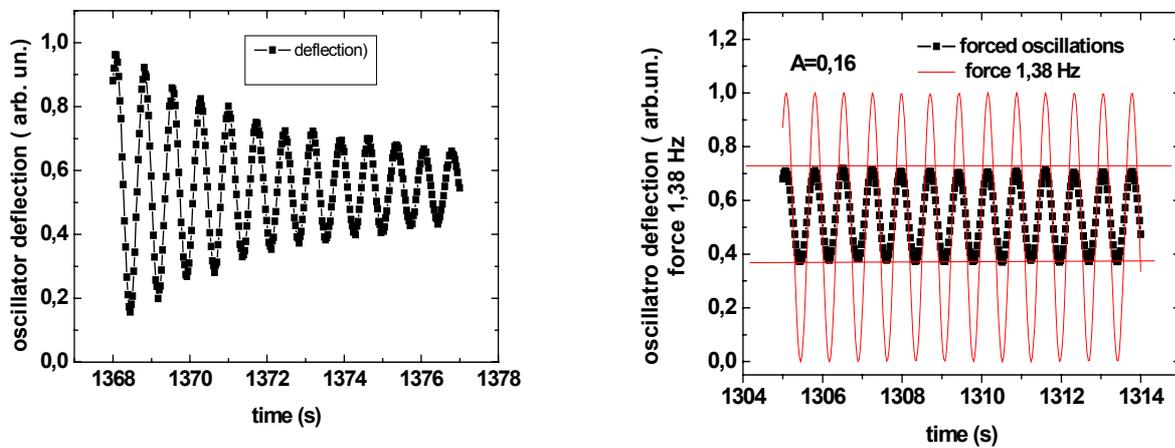

FIGURE 3
PRESENTATION OF THE DATA USING ORIGIN 7.4 ENVIRONMENT FOR DAMPED (LEFT) AND FORCED OSCILLATIONS (WITH DEPICTED DEFLECTION - POINTS – AND FORCING FORCE - LINE) (RIGHT); THE DATA WERE FILTERED BY SPLINES AND APPROXIMATED BY CORRESPONDING FITTING FUNCTIONS
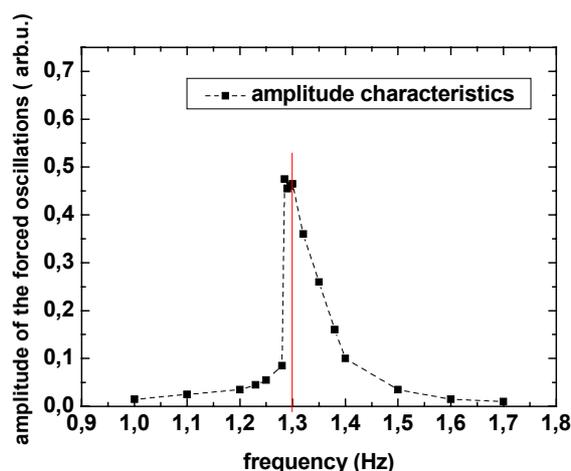
FIGURE 4
THE AMPLITUDE FREQUENCY CHARACTERISTICS OF THE FORCED MECHANICAL OSCILLATOR; THE RESONANCE FREQUENCY
IS DENOTED BY LINE

PEDAGOGICAL SIDE OF THE EXPERIMENT

Pedagogical teach ware within the framework used for the presented remote experiments was carefully designed. The test group of 10 students of different levels of under and postgraduate level was put together within a grant project and a brief seminary on remote experiments in general and physical experiments was organized for them in Trnava University within the seminary for the University staff. Students were then provided with instruction manuals for each experiment explaining the remote experiment basics, brief theory of the phenomena in question and tentative notes on protocol compiling. Their quality proved to be one of the most important circumstances for the good outcome of the experiment. Students were then allowed to measure on any, suitable for them, WEB connections (PC Faculty laboratory, student hostel, at home) and asked to submit the written protocol with the theory, data, achieved results, and conclusions. On top of this, the students were asked to evaluate the technical, pedagogical and other aspects of remote experiments and suitability for their future carriers. The protocols were consulted with the teachers, providing feedback for corrections and their improving.

The important and indispensable part of the pedagogical experiment was the role of the teachers as instructors and evaluators. It turned out to be the second of the most decisive factors as not all the responsible instructors for the laboratory exercise showed interest in the experiment.

Another circumstance worth attantion is introduction and/or strengthening of informatics and experimental techniques oriented subjects to curricula, as the present scope with the students entering the pedagogical experiment turned to be inadequate.

RESULTS – EXPERIMENTAL AND PEDAGOGICAL ASPECTS

The remote experiments in all phases of the process were functioning without any major flaws. Some problems, detected before the start of experiment, were removed by technical solutions or software alternations by the Prague colleagues. The temporal and other reliability of all three setups turned out to be perfect, no substantial supervision was necessary. What turned out to be a major problem was the problem of the WEB data transfer rate from Trnava to Prague, up to now not solved. This complicated the experiment, disabling during most exposed hours of the day the measurements and data transfer, so that the students were forced to measure at less exposed hours. This problem is presently being solved by testing the WEB transfer.

The pedagogical side of the experiment (seminary, instruction manual, teachers counselling) proved to be the most decisive in respect to the outcome of the experiment. The important factor was the extremely good motivation of the students and some of the teachers and interaction of the teachers and students. The seminary and instruction manuals are simply an obligation as well as the feedback to the local teachers and instructors and even feedback to the place or running instruments is sometimes important. Among members of the team is growing the inclination towards of necessity

of the presence of the instructor on the place of the running experiment providing advice or remote help. In this respect the strong argument towards a videoconference was found.

CONCLUSIONS

The remote experiments constitute a new class of e-learning activities that may be classified as dedicated e-learning. The presented experiment was oriented on one group of quantitative experiments of the highest parameters - the level of university physics with real world experiments and with problem solving character. The team involved were the teachers of three universities (Prague, Zlin and Trnava) and the students of different levels of Faculty of Pedagogy, Trnava University in Trnava. The main task was to test the feasibility and applicability of the both hardware, software and teach ware and the pedagogy line, including both students (as subjects) and teachers (as objects).

The main motivation of the project was to test the applicability of the remote experiments for the international university level of quantified experiments with the view of sharing of money and time consuming experiments in long time range among international universities. Another motivation was to strengthen the role of experiments in all forms of teaching and out of school teaching process (e-learning texts, collection of exercises, repetition materials and self choice tests).

The main conclusions are:

- The dedicated e-learning remote experiments are suitable as a self-contained branch of e-learning;
- The remote experiments are suitable for the international exchange at the university level of education in all its forms (lecture, laboratory exercises, self study);
- For the high efficiency of remote experiments the enormous care should be exerted in preparing the introduction explanatory tools;
- The human factor, provided by high level teachers counselling and feedback is another factor influencing the success of e-learning remote experiments;
- The provisions for checking of results and feedback on activities of students aiming at the responsible approach in fulfilling the goals of the teaching process are necessary to introduce.

ACKNOWLEDGMENTS

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