# TEACHERS'ATTITUDES TOWARDS REMOTE EXPERIMENTATION

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***Abstract:*** Physics teachers (and teachers in general) have to face many novelties in the teaching process. They should improve their computer literacy, use progressive teaching tools and methods, support interdisciplinary relations, and integrate Information and Communication Technologies to their classes. One of the solutions of how to innovate their teaching and motivate students is integration of remote experiments – both real and virtual – to the education process. In the contribution, we analyzed the results of a piloting survey among a limited number of physics teachers, and tried to identify the attitudes of the respondents towards remote experimentation. Presented survey is the first insight to the studied subject in Slovakia. The responses revealed their predominantly positive attitudes to remote experiments and readiness to use them in their practice. The results gained in the questionnaire should be decisive not only to the designers of remote experiments but also to their potential users.

***Keywords:*** education, physics, questionnaire, remote experiment, virtual experiment.

## NÁZORY UČITEĽOV NA VZDIALENÉ EXPERIMENTOVANIE

***Resumé:*** Učitelia fyziky (a učitelia vo všeobecnosti) musia čeliť mnohým novinkám vo výchovno-vzdelávacom procese. Očakáva sa od nich, že budú zvyšovať svoju počítačovú gramotnosť, používať rôzne progresívne učebné metódy a pomôcky, podporovať medzipredmetové vzťahy a zavádzať informačné a komunikačné technológie do praktickej výučby. Jedným z riešení ako inovovať svoje hodiny a motivovať študentov, je integrovať vzdialené experimenty – reálne a virtuálne – do edukačného procesu. V príspevku analyzujeme výsledky pilotného prieskumu, ktorý sme uskutočnili medzi učiteľmi fyziky. V ňom sme sa snažili identifikovať názory respondentov na vzdialené experimentovanie. Prezentovaný prieskum je prvým náhľadom na danú problematiku na Slovensku. Odpovede odhalili prevažne pozitívne názory na vzdialené experimenty a ochotu zavádzať ich do edukačného procesu. Výsledky získané z dotazníka by mali byť smerodajné nielen pre tvorcov vzdialených experimentov, ale aj pre ich potenciálnych užívateľov.

***Kľúčová slova:*** edukácia, fyzika, dotazník, vzdialený experiment, virtuálny experiment.

## 1 Introduction

Experimentation in general is considered crucial to physics education at all levels. It is often claimed to support students' understanding of different real-world phenomena and possibly motivate their future physics studies. However, many teachers are forced to restrain the number of experiments in their classes for various reasons. The most serious problems are related to the lack of material equipment in their laboratories, or low number of physics classes. This is one of the reasons why students lose interest in physics classes – they don't understand complicated theoretical explanations supported by mathematical models that simply "don't make sense". They decreasingly see physics as able to contribute to solutions to environmental or medical problems, and increasingly see physics as requiring mathematical ability [12]. Various researchers affirm that students want to do more practical experiments in physics classes [2], [10]. Other studies validate the presumption that experimental activities have positive influence on students' knowledge and understanding of real-world phenomena [3], [11].

A potential solution that is gradually becoming common in abroad is the utilization of the Internet accessible real and virtual laboratories, allowing online experimentation 24/7; the only demand is a computer with an Internet connection. Real remote laboratories allow students and teachers to use high-speed networks, coupled with cameras, sensors, and controllers, to carry out experiments on real physical laboratory apparatus that is located remotely from the student [6]. The remote laboratories available to all users with no demand

for registration and proper for the secondary and also primary school physics education are e.g.:

- Remotely Controlled Laboratories (University of Technology Kaiserslautern, Germany) – 17 remote experiments (e.g. Speed of Light, Photoelectrical effect, World pendulum) – http://rcl-munich.informatik.unibw-muenchen.de/;
- e-Laboratory Project (Charles University in Prague, Czech Republic) – 10 remote experiments (e.g. Water level control, Electromagnetic induction, Diffraction on microobjects) – http://www.ises.info;
- Remotely controlled laboratory (Palacký University Olomouc, Czech Republic) – 5 remote experiments (e.g. Volt-ampere characteristic, Weather station in Olomouc, Monitoring of radioactive background in Olomouc) - http://www.ictphysics.upol.cz/remotelab/index.html;
- e-Laboratory (Trnava University, Slovak Republic) – 10 remote experiments (e.g. Free fall, RLC circuit, Emission of luminescent diodes) – http://kf.truni.sk/remotelab, or http://remotelabN.truni.sk (N = 1-8).

Virtual laboratories comprise a number of simulations presenting idealized real-world phenomena. Examples of virtual laboratories with physics experiments are e.g.:

- Physics Education Technology - PhET (University of Colorado at Boulder, USA) – 90 physics simulations (e.g. Buoyancy, Friction, Microwaves) – http://phet.colorado.edu/;
- Java Applets on Physics (Walter Fendt) – 51 physics simulations in English and Czech, 13 in Slovak (e.g. Newton's Cradle, Doppler Effect, Lorentz Force) – http://www.walter-fendt.de/;
- General Physics Java Applets (B. Surendranath Reddy) – 83 physics simulations (e.g. Rainbow, Polarized Wave, Laws of Kepler) – http://surendranath.tripod.com/Applets.html and many others.

Remote experiments (REs) – both real and virtual – can be implemented to direct education either to supplant or supplement other forms of experimentation. It is up to teachers' experience and expertise which experiments they choose and how they can apply them in the teaching process.

The contribution presents the results of a questionnaire disseminated among a group of 38 Slovak physics teachers participating in two workshops dealing with the current trends in physics education. The questionnaire proved their positive attitudes towards REs and revealed a few weaknesses and misconceptions that being discussed in the paper.

## 2 Results of the survey

Since we have been building and expanding the first in Slovakia Science e-Laboratory, we were interested how e-experiments are utilized in other schools all over Slovakia. We addressed a group of physics teachers in order to identify their attitudes towards remote experimentation. We deliberately chose the teachers who either occasionally or regularly attend various seminars and workshops dealing with modern approaches to science education. Our intention was to set up collaboration with the teachers familiar with the REs technology.

The elaborated questionnaire contained five closed questions and four open questions. We were interested in the possibility to use technological devices in the education process, the frequency of experimentation in their classes, the types of experiments they use, and their opinion of REs.

### *Evaluation of the closed questions*

The group comprised 38 primary and secondary school teachers (12 men). The average length of their pedagogical practice was 19 years (for detailed analysis see Fig. 1). The least experienced teacher was teaching for a year, while the most experienced one for 40 years. The average age in our sample was similar to the national average age of teachers [13].

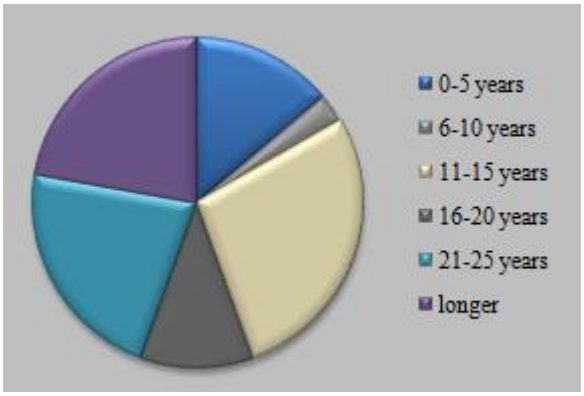
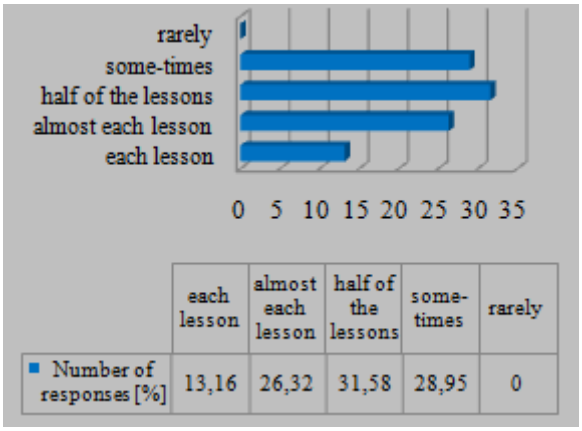



***Fig. 1:*** *The length of pedagogical practice*

The prerequisite of REs implementation to the education process is a computer with an Internet connection at minimum. Nearly 82 % of the teachers involved in the survey had the access to the IT classroom during the majority of their classes, while 89.5 % of them can take the advantage of a computer with a data projector and an Internet connection, so that they have appropriate conditions for using REs in their classes.

In the next part of the questionnaire, we focused on the frequency of experimentation in their classes (Fig. 2). Experimental activities during half of the lessons were reported most frequently. Only five teachers claimed they conducted experiments in each lesson. We consider these results positive, as none of the teachers chose the options "rarely" and "never". The most often they conduct various experiments in mechanics (motions, inclined line, friction and energy), electricity and magnetism (circuits, Ohm's law, Kirhoff'scircuits laws and Faraday's law), optics (reflection and refraction of light) and hydromechanics.




| | each lesson | almost each lesson | half of the lessons | some-times | rarely |
|---|---|---|---|---|---|
| Number of responses [%] | 13,16 | 26,32 | 31,58 | 28,95 | 0 |

***Fig. 2:*** *Frequency of experimentation in physics classes (in percentage)*

Our previous surveys mapping students' attitudes to physics lessons [5], revealed lower frequency of experimentation than the teachers surveyed claimed. We suppose that it was due to the fact that the respondentsconsisted of those active ones, interested in sustainable education and self-improvement.

The last closed question was focused on the types of experiments used in the classes. Since involved were predominantly senior teachers, we presumed the dominance of real hands-on experiments. Our assumption was affirmed, as "demonstrations" and "simple experiments" prevailed in their answers (Fig. 3). Gratifying was the finding that 22 teachers also used REs in their classes – although only one of them used real remote experiments and the rest of them used simulations. The average length of the practice of teachers using REs was nearly 18 years. It corresponds with the average length of the practice of the whole sample of respondents.

The above-mentioned findings did not prove the dependence between the use of REs and the length of the pedagogical practice. In general, our respondents do not refuse progressive forms of experimentation, yet giving preference to hands-on experiments in their teaching practice.

Five respondents chose one type of experiment, the rest of them chose more than one type. Two out of the above-mentioned five teachers (beginning teachers) chose "virtual experiment" as the only type of experiment used in their classes. The most frequent was the combination of demonstration, simple and virtual experiment. This finding was later confirmed by the analysis of their attitudes towards REs; many of them considered REs as a good method when combined with other types of experiments.

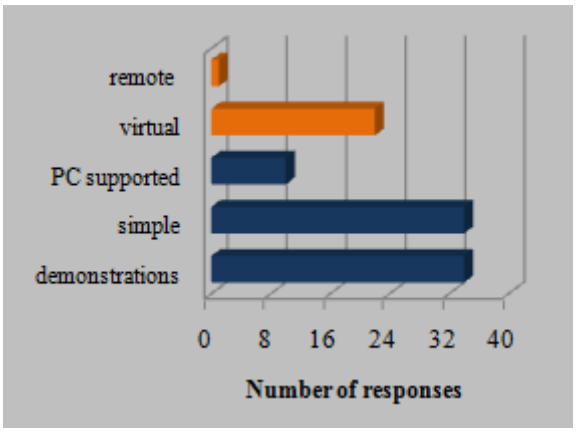



***Fig. 3:*** *Types of experiments used in physics classes*

***Evaluation of the open questions***

Evaluation of the closed questions proved that our respondents were familiar with the existence of various simulations and virtual experiments. Situation in the field of real remote experiments is much worse; only 13 respondents (one-third) knew about their existence. We wanted to identify the source from which they learned about the real remote experiments. Majority of the responses mentioned various conferences, seminars and workshops for the physics and science teachers. Two of the respondents had some practical experience with the robotic telescope in Hawaii (see http://www.faulkes-telescope.com/). However, only one respondent found some information about the real remote experiments in various articles, and only two of them found remote experiments on the Internet.

In the next section, we want to focus on the attitudes of the respondents towards REs – real and virtual. Fig. 4 represents individual statements scaled from "negative statement" to "positive statement".

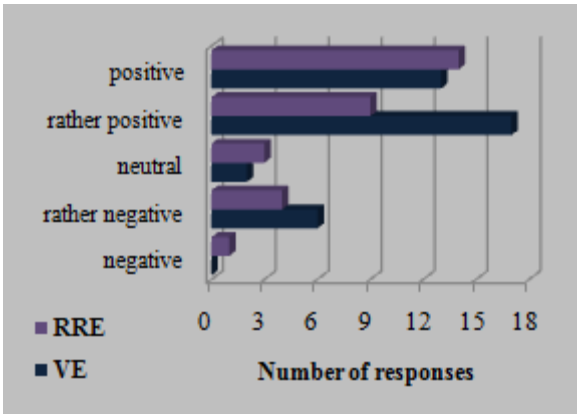



***Fig. 4:*** *Attitudes of the teachers towards real remote (RRE) and virtual experiments (VE)*

There was only one respondent claiming negative attitude to real remote experiment and complaining about the frequent dropouts of various remote experiments. The category "rather negative than positive" comprised the following statements:

- I prefer real hands-on experiments;
- Students are passive;
- It is important to know foreign language;
- It is time-consuming.

"Rather positive than negative" category contained e.g.:

- It is good for the presentation of difficult experiments;
- It is a solution in the case a teacher doesn't have the experimental tools;
- It is proper when combined with other forms of experimentation;
- It is an option of after-school activities, etc.

The average length of the pedagogical practice of teachers who expressed either "negative" or "rather negative than positive" opinions was 16.2 years. We can conclude that junior teachers in the sample surveyed were more critical to REs than senior teachers.

Gratifying were the following answers categorized as "positive attitudes":

- This is the proper way!
- I am looking forward to using it;
- It's very attractive for students;
- Students appreciate their own work and experience;
- It's ideal for students who are fond of physics.

This part confirmed the predominantly positive attitudes of the respondents towards REs – both virtual and real. Although they still prefer hands-on experiments, they see the potential power and effectiveness in REs. In the following part we want to analyze some of the answers and draw the conclusions.

***Discussion of the results***

The teachers surveyed revealed many heterogeneous attitudes towards REs. It is our task to summarize their responses, sort them out, illustrate them in a graph, as well as analyze them and draw the important conclusions.

One of the considerable and repetitive opinions confirmed the use of REs when a teacher does not dispose the experimental equipment. Many Slovak schools have only very poor laboratory equipment, therefore teachers either use their own home-made simple tools to demonstrate various real-world phenomena, or explain these phenomena without proper demonstrations. REs offer another solution to the problem: teachers can perform a wide range of various experiments, simple or more complicated ones, without expensive experimental apparatus. Thus, REs save their money and time (since teachers do not have to "waste" their time by preparing the equipment).

Often discussed was the possibility to conduct complicated and dangerous e-experiments with no risk of injury to teachers or students. Let us complete this statement with a few practical

examples of REs suitable for the secondary (but few of them also for primary) school physics education:

- Study of the photoelectric effect - http://kdt-29.karlov.mff.cuni.cz/index_VA_en.html,http://rcl-munich.informatik.unibw-muenchen.de/,http://phet.colorado.edu/en/simulation/photoelectric;
- The comparison of different values of the acceleration owing to gravity by means of simple pendulums - http://rcl-munich.informatik.unibw-muenchen.de/, http://www.ictphysics.upol.cz/remotelab/rlab2_run.html, http://remotelab.truni.sk,http://phet.colorado.edu/sims/pendulum-lab/pendulum-lab_en.html;
- Background radiation monitoring - http://kdt-38.karlov.mff.cuni.cz/background/experiment.html, http://www.ictphysics.upol.cz/remotelab/rlab5.html;
- Quantum wave interference - http://phet.colorado.edu/en/simulation/quantum-wave-interference;
- Thermal motion of particles - http://phet.colorado.edu/en/simulation/states-of-matter-basics, etc.

In the following section, we intend to disprove some of the statements of the teachers that were confused or incorrect:

- "REs are proper only for the secondary school and university education"– we do not agree with this statement as there is a plenty of simulations designed also for the primary school physics and science education (check e.g. http://phet.colorado.edu/en/simulations/category/by-level/elementary-school); we have much practical experience with the implementation of REs to the primary school education process with good results [1], [4] – pupils like working with them, they are motivated and able to understand the presented phenomena; REs also develop their practical thinking and logic;
- "Students are passive" – students are actively involved in the process of measurement (they control the apparatus and change the adjustable parameters) as well as in the evaluation of the real experimental data; the only limitation is that they do not build the experimental apparatus;
- "Students are not present in the laboratory" – in 2007 a comparative research was published [9], in which remote and hands-on laboratories were compared; students did not consider "the physical presence in the laboratory" to be as important as "instructions" and "making reports"; other authors write about the telepresence in the laboratory to "look and feel" as realistic as possible [7], [8];
- "REs are effective but time-consuming" – REs save teachers' time, but only in the case they know how to implement them to direct education; fortunately many authors of real remote or virtual experiments also prepare questions and tasks for students, so that teachers are provided with the prepared materials to be used in their classes (see e.g. http://www.ictphysics.upol.cz/remotelab/doku/PL_exp3.pdf, http://kf.truni.sk/index.php?option=com_content&view=article&id=135&Itemid=189, http://e-materialy.net76.net/, http://phet.colorado.edu/en /for-teachers).

## 3 Conclusion

In the paper, we presented the attitudes of a small group of the Slovak physics primary and secondary school teachers towards the implementation of remote experiments, both virtual and real, into direct education process. Their opinions were investigated by means of a questionnaire that was disseminated during two workshops aimed at the development of physics education at the Slovak primary and secondary schools.

The main conclusions of the presented paper may be formulated as follows:

- Nearly 90 % of the respondents of the questionnaire have at least a computer with an Internet connection and a data projector, so they could work with REs in their classes;
- Although the teachers preferred the classic types of hands-on experiments – demonstrations and simple experiments – they also used virtual simulations in the education process;

- Only a third of them was familiar with real remote experiments, so that we should pay more attention to informing teachers about the possibilities of remote experimentation;
- We did not identify the dependence between the preference of a certain type of experiments and the length of the pedagogical practice of the teachers;
- Teachers revealed predominantly positive attitudes to REs – both real and virtual;
- The respondents preferred the combination of various types of hands-on experiments with REs to the exclusive use of REs in education;
- They would use REs when the real hands-on experiments are either complicated and expensive or dangerous;
- As some of the respondents considered the implementation of REs into direct education as time-consuming, they should be provided with some specific samples of worksheets or projects.

Finally we can conclude that our pilot survey provides some useful findings that should betaken into consideration during construction of remote laboratories or designing of primary and secondary school physics syllabi.

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