

# REMOTE EXPERIMENTS IN SECONDARY SCHOOLS AND HIGHER EDUCATION

**Marius Šadauskas, Airina Volungevičienė**

*Vytautas Magnus University, Lithuania*

## Summary

Online learning becomes more and more popular which enables students gain knowledge and get certificates or diplomas by learning online. However some subjects such as science, technology, engineering still requires practical classes in laboratory. This can be changed by using remote laboratories, which are the same laboratories, containing real equipment, but controlled by computer via Internet. In this paper traditional hand-on and remote laboratories are compared, needs of ICT skills, knowledge and remote experiments are described. European Lifelong Learning project "OLAREX" experience and results is used in this paper to show current situation in Europe in context of remote experiments.

**Keywords:** remote experiments, remote laboratories, digital competences, online learning, open education resources.

## Introduction

Teaching and learning has changed during few decades. Technology started to change process of education, more ICT (information communication technologies) instruments and tools involved in teaching and learning. Online learning is used in secondary schools, universities all over the world, it gives students new look and new feel of learning. Innovative learning approaches give students more motivation and confidence to learn new things, to explore whole process from beginning to the end.

Physics, Mathematics, Biology subjects usually consist of hand-on experiments which usually are performed in school or university laboratories. During experiments in laboratory classroom students has opportunity to perform real experiment, work with real systems, but as Luis Gomes (2009) mentions traditional laboratories also known for their expensive equipment, limited space, maintenance staff. Remote experiments are quite new compared to traditional laboratory experiments. All experiments are performed with real equipment and student can take part in experiment, watch it or change equipment parameters. Remote laboratories are accessible 24 hours per day, 7 days per week, which gives students more freedom to perform experiments when they are ready and have time for that.

It is not a question any more if remote laboratories are necessary in STEM (science, technology, engineering, mathematics) education, the question is how to implement remote experiments in secondary schools and higher education. Many studies showed that teachers and students are interested in remote experiments (Dziabenko, Zubia, Orduna, Angulo 2012). However it is hundred remote laboratories over the world but not many of them are used actively. It is necessary to analyze current situation and promote remote experiments in secondary schools and higher education. The project "OLAREX: Open Learning Approach with Remote Experiments" (No. 518987-LLP-1-2011-1-ES-KA3-KA3MP) has been funded with support from the Lifelong Learning Programme (KA3 - ICT) from European Union. This project goal was to innovatively implement ICT-based learning materials, remote experiments, and e-didactic methods into formal and non-formal lifelong learning settings. This study refers OLAREX project results and experience as well as other authors' books, studies in remote laboratories field.

**Aim of the study** is to define the possibilities to use remote experiments in secondary schools and higher education.

### **Objectives of this study are:**

1. To describe traditional and remote experiments.
2. To find out teachers ICT skills;
3. To identify the pre-conditions for application of remote experiments in education;
4. To familiarize teachers with remote experiments;

## 1. Traditional and remotely controlled experiments

Most people who already finished secondary school and universities remembers traditional physics lessons where they had to perform various experiments: to measure voltage, current, impedance, to use breadboard to make electrical circuit with various components such as capacitor, resistor, bulb. Very expensive devices were used for some of these experiments. In nowadays teachers have possibility to teach students by using remote laboratories and perform all these experiments virtually using computer and the Internet. It needs

to be mentioned that remote experiments are different from virtual simulations (Ma, Nikerson 2006). The main difference is that virtual simulations gives results simulated by software (e.g. MATHLAB, LabVIEW, ORCAD) while remote experiment are real experiment performed by real equipment but controlled remotely.

There are a lot of various remote laboratories over the Internet which has different working scenarios, different architecture, Alves, Gericota, Silva (2007) identifies 7 typical components of remote laboratory:

1. The remote experiment itself.
2. Instrumentation devices and equipment which allows control experiment.
3. A laboratory server which will assure the control and monitoring of the experiment.
4. A server which will provide remote user connection with laboratory server through the Internet. This environment also includes booking system where remote users can reserve time for their remote experiment, learning material, information about experiment. This can be integrated in Learning Management System (LMS) such as Moodle.
5. Online webcam which can be used by remote user to follow how experiment is performed.
6. Collaborative tools which allows remote users to communicate and work in groups.
7. All necessary plugins and special programs associated with remote experiment have to be available.

Technology enhanced learning helps teachers to educate students in new innovative and more interactive ways, remote experiments do the same. Remote laboratories are new way to teach students STEM subject at secondary schools and higher education. It can also be cost-effective way to provide remote experiments as school or university doesn't need to buy equipment which can be very expensive and/or fragile (Nedic, Machotka, Nafalski 2003). Remote experiments eliminate some boundaries which are well known in traditional laboratory classroom:

- limited number of students in the laboratory;
- limited time;
- some equipment are shared by all students;
- equipment is broken or not working correctly.

Remote experiments eliminated these boundaries as it has limitless number of students in the laboratory, it is available 24 hours per day, 7 days per week, equipment is safe and cannot be damaged physically by students. Detail comparison of traditional and remote laboratories is provided in Table 1.

**Table 1. Comparison of traditional and remote laboratories**

Laboratory type	Positive aspects	Negative aspects
Traditional laboratory	interaction with real equipment interaction with teacher realistic data collaborative work	limited time limited students expensive equipment supervision required
Remote laboratory	interaction with real equipment realistic data accessible 24/7 though computer no need to buy expensive equipment	virtual presence in the Laboratory

## 2. Teachers ICT skills and knowledge

Remote experiments are related with technologies, so it is important to know what ICT skills and knowledge teachers have. To study current situation, online questionnaires were prepared and distributed during OLAREX project in partner countries Bulgaria, Austria, Hungary, Poland, Lithuania and Spain. Questionnaires were translated in national languages. Target groups of these questionnaires were secondary school and university students, teachers, administrative and management staff.

It is important to stress out main skills which take part in nowadays learning. All these skills are called digital competences and are mentioned in questionnaires. One of the most important digital competences is information management. Now when we have a lot of information available online it is crucial to be able to locate it, identify it and organize it in that way which best fits school curriculum.

Another important digital competence is collaboration. It is important to always refresh your information and be in a head, in order to do this you have to be active in online networks & communities, link with other colleagues, participate in conferences, seminars.

As information is changing school curriculum also changes, new content should be created, new knowledge should be build. To do this digital competence Creation of content & knowledge is necessary. To

create new content teachers can use various open educational resources (OER), using Creative Commons licensing use the material and adapt it to their needs and create new curriculum for their subjects.

Last but not least digital competence which is very important is Technical operations. In order to successfully use newest material teachers have to be able to use various technologies and media, also perform various tasks or give students assignments through digital tools. For example using interactive online mind maps to solve problems with all class students, to show and perform remote experiments using computer or to show slides using Slideshare, Prezi.

During two months 1025 students, 319 teachers, 64 administration staff and 40 management staff participated in the survey. Most teachers who participated in survey have Master degree and more than 10-20 years teaching experience.

Teachers have been asked to tell about their ICT skills and competences. Results were positive as most teachers have ICT skills and use it in daily basis and in their curriculum. Most teachers have very good or good knowledge about hardware and main software such as MS Word, Excel, Power Point. Teachers communicate with students by emails, forums, social networks (Facebook, Twitter, Google+). They also use learning management systems such as Moodle, WebCT, Blackboard. Figure 1 shows how often teachers from uses various technologies and ICT tools for their curriculum.

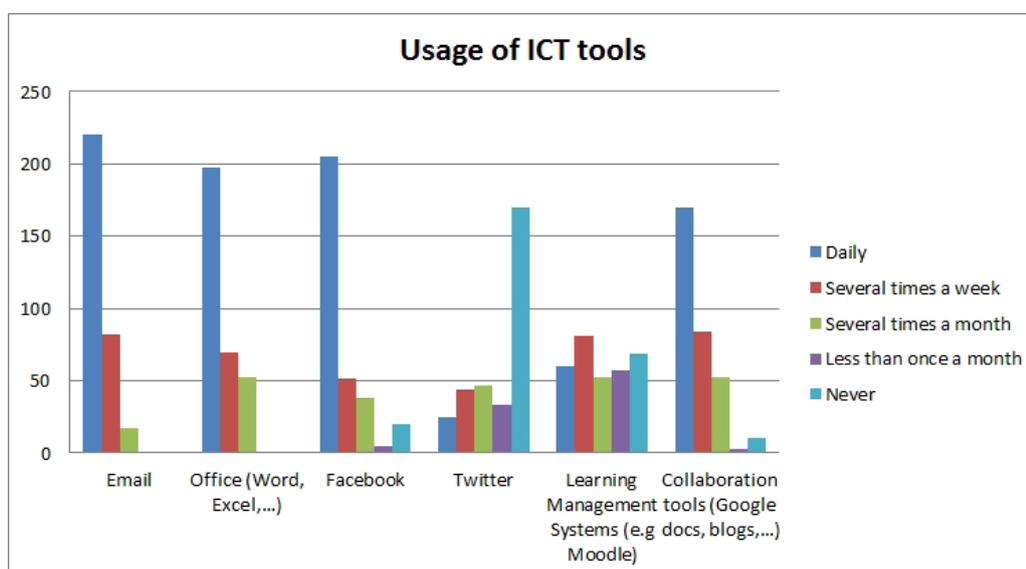


Figure 1. Teachers usage of various technologies and ICT tools.

During questionnaire teachers were asked to choose learning modules and training courses which they would like to learn during online training. Total 8 learning modules with remote experiments and 10 training courses were offered for teachers. From the results the following most popular 5 training courses and 6 learning modules were created. Training courses: Designing curriculum for Moodle virtual learning environment; Empowering education: How choose ICT instruments and applications for purpose of your curriculum; Using ICT for presentational and educational purposes in the museum; Transforming curriculum with remote experimentation: how to integrate it in secondary school classroom; ICT – enhanced Research and Professional Development. Learning modules: Black body radiation of common light sources (Physics, Optics); Farm Experiment: From an egg to a baby chick, step by step (Biology); Working as a computer – Logic gates (Technology & Mathematics); Analogue circuits measurements (Physics); How does the current flow? (Physics); Easy Java Simulation for Phys&Sports (Mechanics, Sport).

### 3. Pre-conditions application of remote experiments in education

Remote experiments are quite new method of teaching and of course not all teachers are familiar with remote experiments. To find out current situation questionnaire about remote experiments needs were developed. Teachers were asked if they are familiar with remote experiments, do they know what is remote laboratory and remote experiments, are they interested to learn how to perform remote experiments and implement them in their curriculum. Results shows (Dziabenko, Zubia, Orduna, Angulo 2012) what more than 80% teachers who participated in survey do not know what remote experiments are but most of them (95%) think that it would be useful instrument in their schools and they would like to try remote experiments.

However successfully perform remote experiments with students it is important to increase their motivation and interest as usually students do not show high interest in learning. Methodological issues stressed out by Herrera, Alves, Fuller, Aldunate (2006) are important in order to motivate students and to provide them collaboration tools, material and other necessary information:

- Number of participants: to define if the lab is individual or for a group.
- Interaction tools: all possible interactions must be considered (students-students, student-tutor, tutor-students, student-contents).
- Other tools: coordination module for accessing the experiment (schedule), discussion forum, text chat, voice chat, videoconference, content management, etc. All these tools could be joined in some Learning Management System (LMS) in order to facilitate the location and use of them.

Also the following needs should be considered in the context of course content:

- Theoretical guide of the experiment: it considers all necessary theory for understanding and carrying out the experiment.
  - Laboratory guide: it specifies the activities that must be performed step by step.
  - Experiment help: it includes help from the technology point of view. It should be included in the experiment interface.
  - Expected results guide: it specifies the report expected, that is, the result of the experiment (sections, format, delivery instructions, etc.).
- School which would like to use remote laboratories for their curriculum should consider these criterias:
- Do school teachers have necessary ICT skills and competences to use remote laboratories and teach students.
  - Does school teachers are motivated to use remote laboratories and willing to adopt it to curriculum.
  - Does school has budget for teachers training in using remote experiments.
  - Does teachers are willing go for training courses.
  - Does school has basic ICT equipment such as computers, internet connection, projectors in classrooms.

#### 4. Online training for teachers

During OLAREX project (518987-LLP-2011-ES-KA3-KA3MP) online pilot training for secondary school and higher education teachers was organized during 4<sup>th</sup> May, 2013 – 1<sup>st</sup> July, 2013. The main project goal was to innovatively implement ICT-based learning materials, remote experiments, and e-didactic methods into formal and non-formal lifelong learning settings. The project aims were to define the school/academia ICT needs for knowledge and skills in the STEM; build teachers', students', and museum employees' e-didactic competences in the STEM; develop practically-oriented learning modules with remote experiments and integrate contents and functionality in e-learning portal and enhance and modernize the teaching/learning tools and methods for formal and non-formal lifelong learning institutions. Within OLAREX project 5 training courses and 6 learning modules were created and translated in all partners national languages – Spain, Austria, Hungary, Bulgaria, Poland, Lithuania. Training courses were oriented to online learning, ICT usage in education and remote experiments integration in curriculum.

The image shows a screenshot of a Moodle forum discussion. It contains three posts, each with a header bar indicating the subject, author, and date. The first post is by Aleksandr Kanarskas on Thursday, 14 March 2013, at 07:46 AM. The second post is by Vilma Pl on Friday, 15 March 2013, at 08:32 AM. The third post is by Virgilijus Juknevičius on Saturday, 16 March 2013, at 03:05 PM. Each post includes a text area and a set of action links (Show parent, Edit, Split, Delete, Reply) at the bottom right.

Re: Diskusijų forumas beismokantiems lietuvių kalba  
by Aleksandr Kanarskas - Thursday, 14 March 2013, 07:46 AM

Sveiki,  
palaikau konferencijos mintį, palankiu laiku mielai prisijungčiau.  
Siūlykite laiką :)

Show parent | Edit | Split | Delete | Reply

Re: Diskusijų forumas beismokantiems lietuvių kalba  
by Vilma Pl - Friday, 15 March 2013, 08:32 AM

Aš taip pat palaikau vaizdo konferencijos idėją, bet tam turėtų būti parinktas laikas po pietų, nes iš ryto visi būna darbe...

Show parent | Edit | Split | Delete | Reply

Re: Diskusijų forumas beismokantiems lietuvių kalba  
by Virgilijus Juknevičius - Saturday, 16 March 2013, 03:05 PM

Po Kretingoje vykusios konferencijos sugalvojau išbandyti savo jėgas Moodle. Kol kas perskaičiau teoriją, ben norisi ir praktikos, ką nors pačiam sukurti. Užsisakiau vietą nemokamame serveryje ir siunčiu ten moodle instaliacinius failus. Manau, kad kai pradėsiu dirbti praktinius darbus - iškilis ir daug klausimų ir problemų. Tik kad užtektų kantrybės ir laiko jiems spręsti. Kai oras atšils ir laiko tam neliks.

Show parent | Edit | Split | Delete | Reply

Figure 2. Forum discussion in Moodle LMS.

During pilot training pedagogical and technical help were assured in all partners languages. As partners

had experience in organizing online training courses all necessary information was provided for teachers. Theoretical part of remote experiments and training courses were provided. After this part teachers had assignments where they practically tried and performed remote experiments. Courses were structured in same format which allowed teacher to navigate through all material easier. Many participants actively participated and discussed using various collaboration tools, such as email, chat and discussion forums (see Fig. 2).

## 5. Results and feedback

During online training more than 270 teachers registered. Teachers from 14 different countries participated in online training (see Fig. 3). Most teachers registered from Lithuania - 83, Hungary - 74 and Bulgaria - 59.

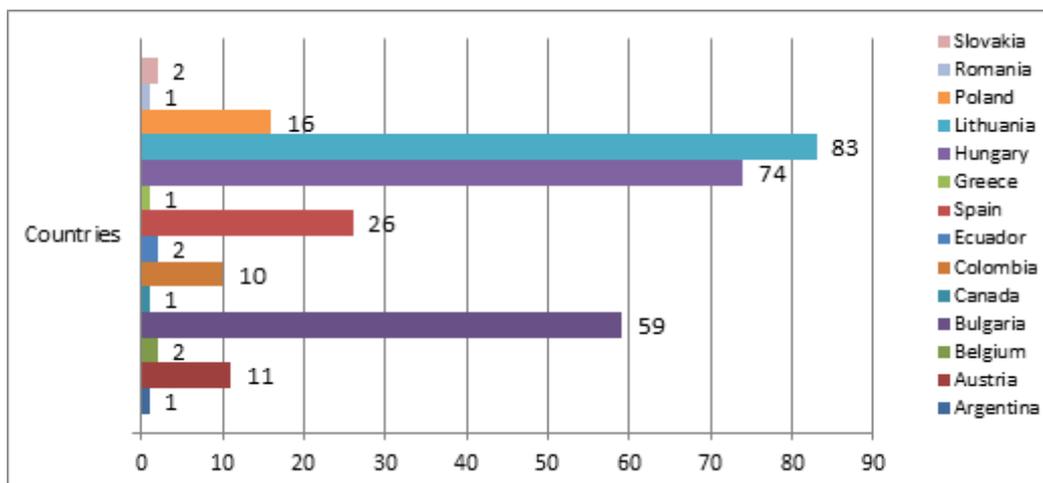


Figure 3. Teachers from 14 different countries registered.

After online training feedback forms in all national languages were prepared to find out teachers opinion about organized training and what should be improved. Teachers were asked to define their level of achievements acquired according to the set learning outcomes of the course, organization process and what collaboration methods and tools they were used during training. Results of teacher's level of achievements acquired according to the set learning outcomes of the course (see Fig. 4):

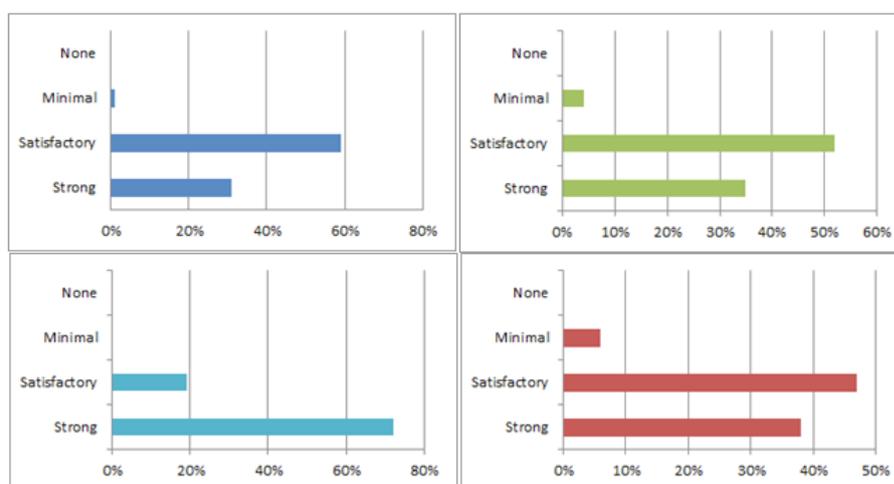


Figure 4. Achievements acquired according to the set learning outcomes of the course. Lithuanian teachers answers.

Teachers were asked few questions about online training course organization: 1. Content of module was understandable, 2. The volume of activities was equally distributed during the module, 3. Activities were clear, 4. Tools were accessible when they were necessary, 5. Support and help was accessible when it was needed. The results are shown in Figure 5.

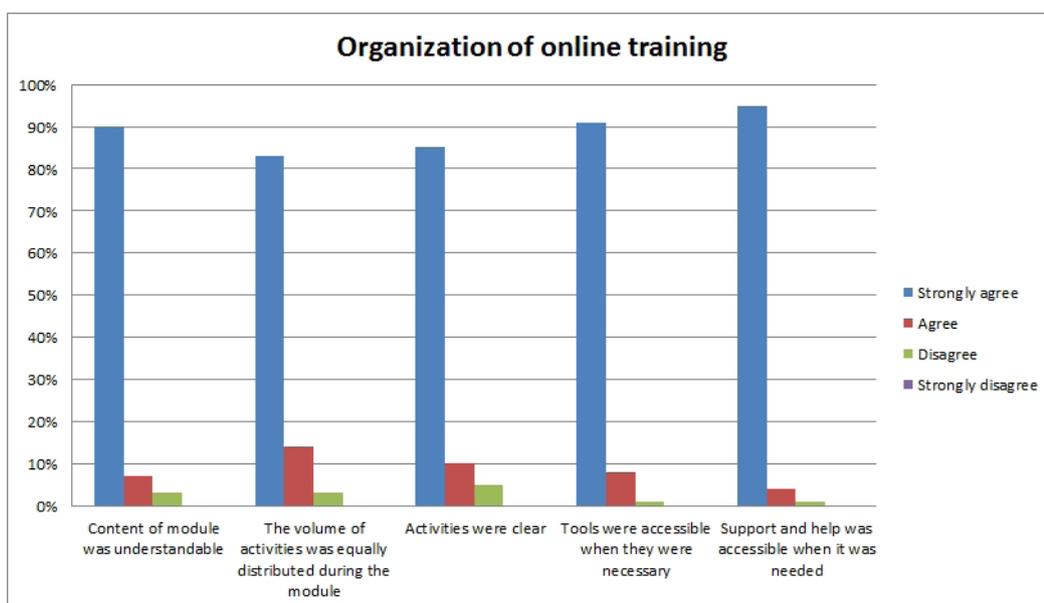


Figure 5. Organizing course. Teachers answers.

To sum up all feedbacks we can clearly see that teachers were very happy having these online training courses, they gained new technological and pedagogical experience. Teachers were very active in communication, they have used a lot of different communication and collaboration tools which is very good as it can be seen that teachers are not afraid of ICT and new technologies.

## Conclusions

Teaching and learning concept is changing because of new innovative technologies which create new interactive and interesting ways of learning. Teaching methods changed during few decades as changed and teaching environment. However studies in STEM subject still requires students to participate in laboratory classroom and work with laboratory equipment. These hand-on experiments are also changing because of technological innovations. Now students can perform real experiments using remote laboratories and controlling equipment remotely using computer.

Remote experiments are new way of teaching and learning, many studies showed that teachers and students are very interested in remote experiments and would like to use these experiments at their schools and universities. OLAREX project results shows that 95% of teachers were interested in remote experiments.

Organized online training for teachers shows that they are very interested in these experiments as within 3 months more than 270 teachers registered for online training. After training collected feedback results showed that most teachers gained new technological and pedagogical experience.

However remote experiments are still not very popular in schools and higher education. Most teachers still use traditional hand-on experiments in their classrooms, but this problem refers not only to teachers but also to administrative staff and local education institutions. The following institutions should start implementing remote experiments in education in national level.

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## Santrauka

### NUOTOLINIAI EKSPERIMENTAI VIDURINĖSE MOKYKLOSE IR AUKŠTAJAME MOKSLE

Sparčiai tobulėjančios naujosios technologijos daro didelę įtaką ir mokslo sektoriuje. Nuotolinis mokymas(-is) tampa vis populiariesnis visame pasaulyje. Studentai gali įgyti naujų žinių, baigti studijas ir įgyti sertifikatus ar diplomus mokydamiis nuotoliniu būdu. Tačiau kai kuriems dalykams, tokiems kaip gamtos mokslai, informatika, inžinerija vis dar reikalingi realūs praktiniai užsiėmimai laboratorijose. Realūs užsiėmimai gali būti pakeisti į nuotolinius panaudojant nuotoliniu būdu valdomas laboratorijas, tai yra tokios pačios laboratorijos, kuriuose yra įrengta ta pati reali įranga, tačiau visos įrangos valdymas yra atliekamas nuotoliniu būdu panaudojant kompiuterį ir internetą. Nuotoliniu būdu valdomos laboratorijos tampa vis populiariesnės vidurinių mokyklų ir aukštojo mokslo institucijų tarpe. Tai yra ekonomiška alternatyva realioms laboratorijoms, nes ta pačia laboratorija gali naudotis keletas institucijų. Šiame straipsnyje yra lyginamos tradicinės ir nuotoliniu būdu valdomos laboratorijos, aprašomi reikalingi IKT įgūdžiai ir žinios bei nuotolinių būdu valdomų eksperimentų poreikis. Straipsnyje panaudota Europos mokymosi visą gyvenimą projekto “OLAREX” patirtis ir rezultatai tam, kad atskleistų dabartinę nuotoliniu valdomų eksperimentų situaciją Europos lygmenyje. Po projekto atliktos apklausos, kurioje dalyvavo 1025 studentai, 319 mokytojų ir dėstytojų iš Bulgarijos, Austrijos, Vengrijos, Lenkijos, Lietuvos, Ispanijos, paaiškėjo, kad mokytojai yra susidomėję nuotoliniais eksperimentais, net 95% respondentų parodė susidomėjimą ir norėjo įgyti daugiau žinių apie šiuos nuotoliniu būdu atliekamus eksperimentus. Įvykdžius mokymus, kurie truko 3 mėnesius, juose užsiregistravo 270 mokytojų bei dėstytojų iš 14 skirtingų šalių. Po mokymų atlikus grįžtamojo ryšio apklausą buvo gauti teigiami rezultatai – dauguma mokymų dalyvių įgijo naujos technologinės ir pedagoginės patirties.

**Esminiai žodžiai:** Nuotoliniu būdu valdomi eksperimentai, nuotolinės laboratorijos, skatimeninės kompetencijos, nuotolinis mokymas(-is), atviri švietimo ištekliai.