DOI: 10.5604/01.3001.0010.4828

E-LABS – ADVANCED E-LEARNING

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Abstract. *The aim of this article is to describe the development of distance learning techniques which opened the possibilities of conducting laboratory activities. In effect there emerged e-labs used for practical activities in the form of e-learning. Laboratory devices are remotely controlled, their management is accomplished via the Internet. This article presents exemplary e-labs, where students participate in didactic activities, allowing university teachers to do research and perform experiments. Some of the presented e-labs can be used to conduct experiments for persons who are logged in as "visitor".*

Keywords: distance learning, e-learning, e-labs, virtual devices

E-LABS – ZAAWANSOWANY E-LEARNING

Streszczenie. *W artykule opisano rozwój technik nauczania na odległość, który doprowadził do możliwości prowadzenia zajęć laboratoryjnych. Powstały e-laboratoria, dzięki którym możemy prowadzić zajęcia praktyczne w formie e-learningu. Aparatura laboratoryjna jest nadzorowana zdalnie, zarządzanie odbywa się przy wykorzystaniu sieci Internet. Zaprezentowane zostały przykładowe e-laboratoria, które umożliwiają studentom realizację zajęć dydaktycznych, a pracownikom naukowym uczelni prowadzenie badań i przeprowadzanie eksperymentów. Część z e-laboratoriów umożliwia przeprowadzenie eksperymentów zalogowanym osobom jako „gość".*

Słowa kluczowe: nauczanie na odległość, e-learning, e-laboratoria, przyrządy wirtualne

Introduction

The characteristic feature of distance learning, which defines this model of teaching, is the fact that teachers and learners (students, course participants) are located remotely. The distance between the student and the learner does not exert any significant influence during the learning process. The most relevant quality of this model is that activities are not conducted in the classroom, which is included in the university resources. The face-to-face contact between the teacher and the learner is replaced by such means as the Internet, television, videoconferences provided by radio and satellite means as well as storage media (CD, DVD, USB). This type of teaching is referred to in a number of ways, as remote teaching, distance learning, virtual education, e-learning, e-education, e-training, Internet-based study, study via the Internet [2]. Very often distance learning is described by English coinages, the most typical term being e-learning. Apart from this term, in the Polish literature one may come across such expressions as: distance learning, distance teaching, open education [2].

1. Development of distance learning

Distance learning is not a novel educational method. Its origins date back to the year 1840 – Fig. 1.

Distance learning was first used in the educational process in England in 1840, when the study materials in the form of coursebooks and specialist literature were mailed by post. After the invention of the radio, radio educational programmes appeared, initially in the US and then in Australia. The next stage in the development of distance learning was the use of television, which was becoming more widespread and more popular than the radio, since it offered the possibility of transmitting sound and image at a distance. It was more effective in the process of distance learning. In Poland, the first educational programme was broadcast in 1960. The popularisation of computers led to their implementation in the process of distance learning. Initially, the study materials were stored on data carriers (CDs, later DVDs) to be opened on a computer.

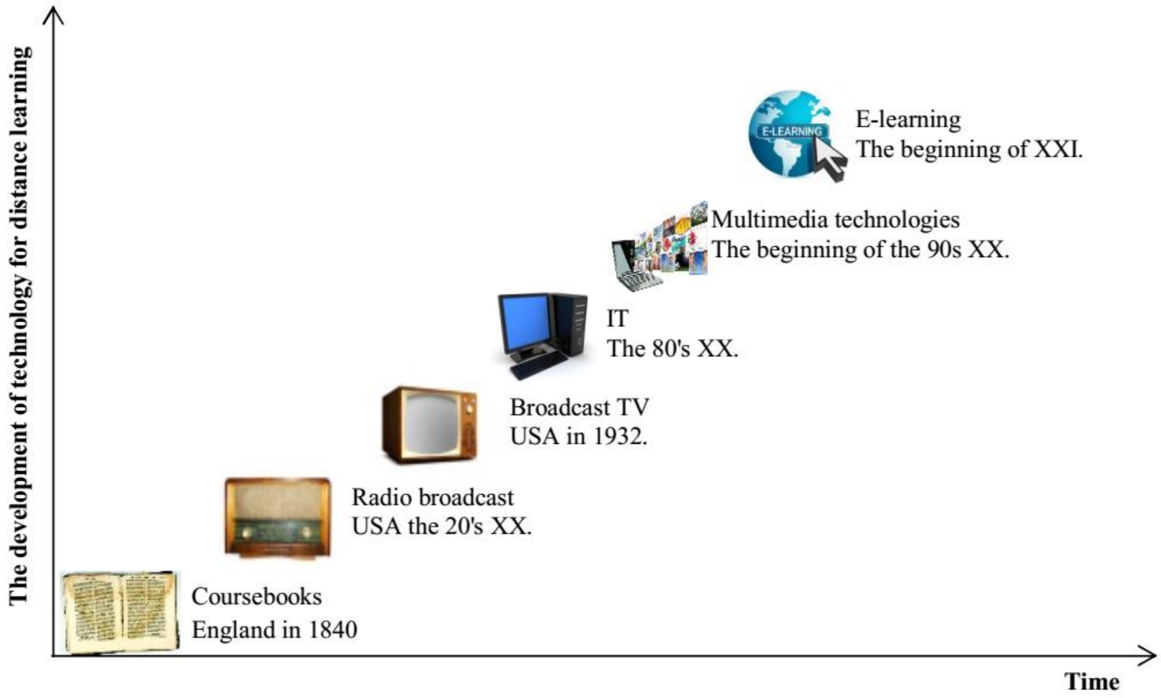

Fig. 1. The development of technology for distance learning

The materials contained textbooks, other books and teaching aids in an electronic version. As the computer technologies were being developed, the study materials addressed to their users contained more and more multimedia technologies. Moreover, multimedia educational aids were created for the needs of distance learning. The progression and common access to the Internet resulted in increasing the importance of distance learning. The term “e-learning” is used in relation to distance teaching, where the transmission means (contact) between the teacher and the learner adopts the Internet network. Modern technologies enable immediate contact between the teacher and the student, in real time, during a videoconference, regardless of the distance between them, which is an additional benefit of e-learning over other distance learning methods [1]. Further advancement of e-learning brought about new forms of teaching on its basis, closely linked with e-learning:

- rapid e-learning (also called: rapid learning, r-learning, 3-minute learning),
- mobile learning (also named: mlearning or mobile e-learning),
- blended learning (or so-called blended education/blended learning, hybrid education),
- edu-marketing (combination of the e-learning concept with marketing) [4].

2. Distance labs

Originally, e-learning activities included such forms of conducting lessons as lectures and classes. Thanks to the development of measurement instruments and multimedia technologies, there appeared a concept of distance labs. The evolution of measurement instruments can be presented as follows:

- 1st generation: analogue instruments without communication interfaces,
- 2nd generation: digital instruments, first communication interfaces,
- 3rd generation: digital instruments with IEC-625 interfaces, allowing to provide full remote instrument control,
- 4th generation: virtual instruments which constitute software representation of real measurement devices.

A distance lab can be defined as a remotely controlled set of measurement apparatuses, built as a system which enables full management via the Internet with available physical devices or their virtual software versions. The exploitation of distance labs offers the following advantages:

- easier and time-unlimited access to the labs,
- reduced costs of learning,
- increased effectiveness of learning,
- new possibilities to educate students and the academic staff.

The distance lab may work in two modes: real and simulation. The work in real mode enables online access to real measurement instruments, which are available through interfaces – Fig. 2. The benefits of such a solution is the didactic value, on the same level as in the case of a real lab. The drawbacks comprise high purchasing costs as well as maintenance of measurement instruments, the necessity to employ operating personnel and limited access to the laboratory. The real mode may be exploited for making measurements for diploma papers by students and conducting projects by the scientific staff.

The work in the simulation mode provides access to virtual devices, which reflect the real measurement system as closely as possible, built for the needs of a given task – see Fig. 3. During the exercise, the results of the measurements which are measured by the instruments, are obtained from the measurement data base. The measurement data base was created from the measurement findings obtained by real instruments. The advantages of such a solution is lack of high expenses connected with purchasing the measurement apparatus, employing operating lab personnel as well as unlimited access to the laboratory (the laboratory can work for twenty-four hours a day). The significant disadvantages of such an approach is diminished versatility of the lab due to the limited capabilities of the simulators and increased loading of information systems in the university resources. The simulation mode can be fully used to conduct lab exercises.

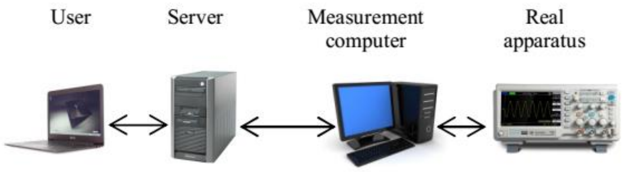

Fig. 2. Work in real mode

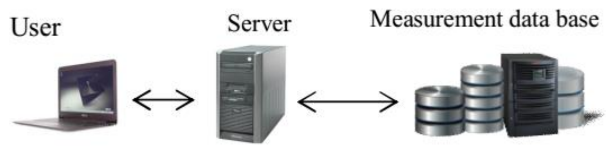

Fig. 3. Work in simulation mode

3. E-lab architecture

Fig. 4 depicts an example of a distance lab. Basing on the sample design, it is possible to build any distance lab in order to conduct research in any scientific field. The users can connect to the distance lab, over the Internet, in order to do research.

The users connect to the server for identification, typing the login and the password. Next the user is certified and the connection between the user and the server is encrypted. The access to the measurement instruments, used in the exercise, is provided by the server. The connection between the measurement computers and the server plus the measurement apparatuses is realised in the Intranet network of the university. In order to secure the data on the server, we should activate the mechanism of making backup copies, daily. Additionally, all the events in the database will be recorded in the event books. In order to prevent modification commands or commands which may destroy the database, the users should be allowed to modify the base to a limited extent, merely.

E-labs provide opportunities to conduct distance lab tasks in a particular field, which mirror a real laboratory. By using two modes of work it is possible to provide real and virtual measurement systems. In addition, it is possible to contribute lab instructions for the tasks, assess the student’s knowledge before commencing the task, allow to make a report on the basis of the measurement results, in accordance with a certain scheme, as well as evaluating the report [6].

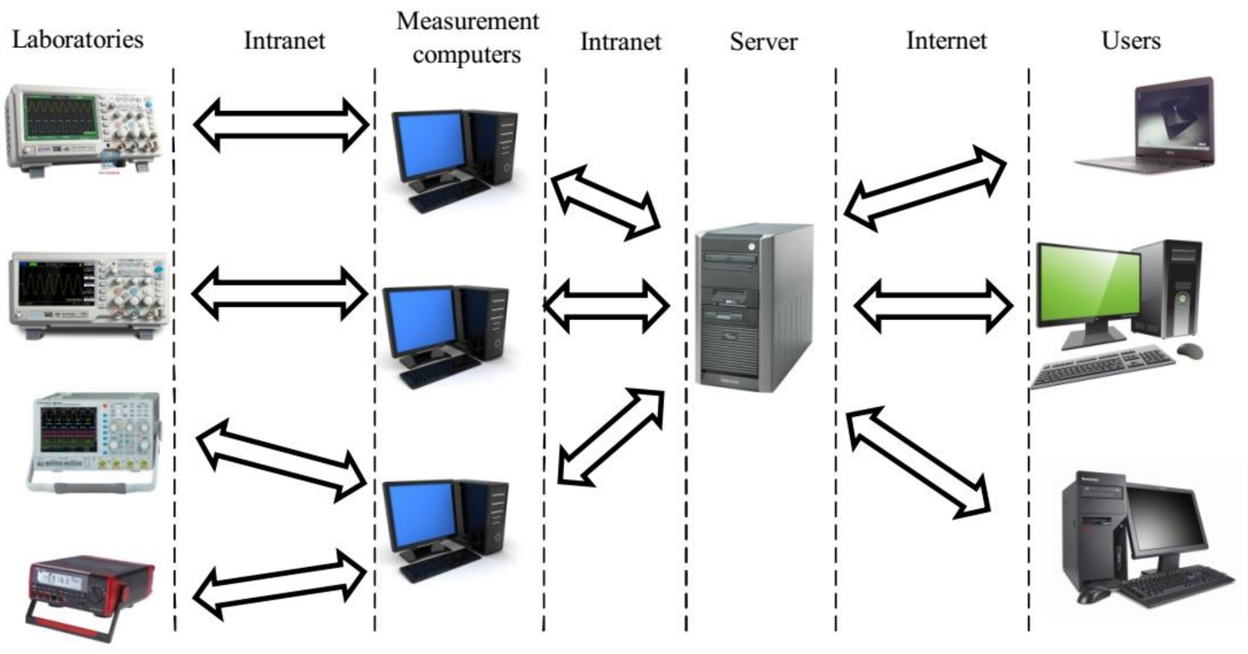

Fig. 4. An example of an e-lab

4. Laboratory exercise

Examples of laboratory exercise was carried out using a remote lab at the NetLab of the University of South Australia which is available via the Internet address http://netlab2.unisa.edu.au [5].

Before the start of the exercises, user should read the instructions available on the laboratory page [7]. There are also available two examples of exercises.

It is possible to perform any exercises with the following elements of the RLC and measuring devices:

- a variable resistor - 4 pcs of ranges: 1 Ω – 11,1 kΩ, 10 Ω – 111 kΩ, 100 Ω – 1,1 MΩ and 1 kΩ – 11,1 MΩ,
- a variable capacitor – 2 pcs of ranges: 1 nF – 11,1 μF and 10 nF to 111 μF,
- a variable coil – range: 1 mH – 11 H,
- a signal generator Agilent 33120,
- a digital multimeter Agilent 34401,
- an oscilloscope Agilent 54624.

The exemplary GUI of elements and measuring devices are shown in Fig. 5.

The aim of the exercise was to study the RC filter (Fig. 6) in the following steps:

- Configuration of the measurement system in the wizard circuit (Fig. 5) according to the diagram (Fig. 6).
- Switching signal generator and digital oscilloscope and test the system in real time using a webcam.
- Setting a sinusoidal signal generator supply voltage 1 Vpp.
- Reading the voltage Vpp on the oscilloscope to the output of the system while changing the frequency of the signal generator in the range of 20 Hz – 5 kHz. The input voltage is displayed on channel 1, and the output signal on channel 2 of the digital oscilloscope, so allowing us clearly see both signals. The GUI of measuring instruments for frequency 20 Hz and 5 kHz is shown in Fig. 7.
- Disconnect all elements of the measuring system and log out of e-lab.

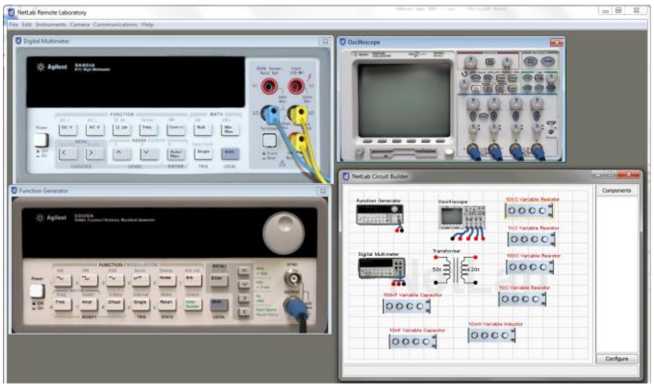

Fig. 5. NetLab GUI

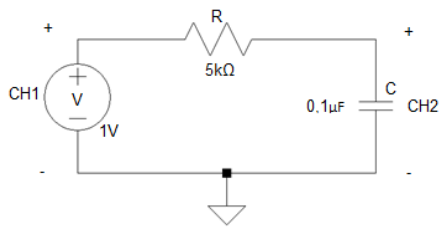

Fig. 6. The diagram of the test circuit

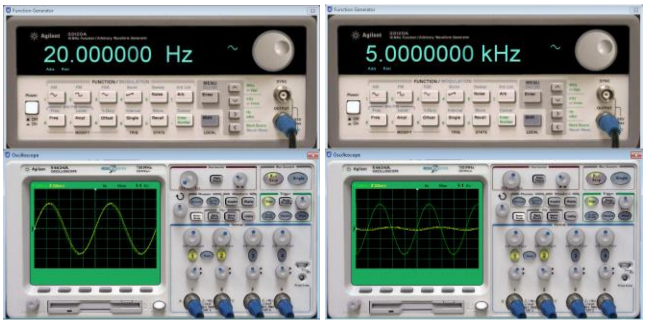

Fig. 7. The GUI of measuring instruments for frequency of 20 Hz and 5 kHz

Table 1. The measuring table

f [Hz]	U2 [Vpp]	
	NetLab	PSpice
20	1,000	0,995
50	1,000	0,987
100	0,949	0,954
120	0,938	0,934
140	0,905	0,914
160	0,899	0,893
180	0,866	0,870
200	0,844	0,847
220	0,822	0,822
240	0,795	0,799
260	0,767	0,775
280	0,740	0,751
300	0,718	0,727
310	0,707	0,716
315	0,701	0,711
318	0,696	0,708
320	0,687	0,705
340	0,674	0,684
360	0,652	0,663
380	0,641	0,642
400	0,605	0,623
450	0,563	0,578
500	0,525	0,537
550	0,493	0,501
600	0,462	0,469
700	0,410	0,414
800	0,358	0,370
900	0,326	0,334
1000	0,297	0,303
1200	0,252	0,256
1600	0,194	0,195
2000	0,151	0,157
2500	0,123	0,126
3000	0,104	0,106
3500	0,090	0,091
4000	0,079	0,079
4500	0,070	0,071
5000	0,062	0,064

On the basis of the measurement results in Table (Tab. 1) was plotted graph of the output voltage of the frequency (Fig. 9) and is given cut-off frequency of the filter, which is 318 Hz. The appearance of the graphical interface of NetLab for the cut-off frequency of 318 Hz with webcam view is shown in Fig. 8.

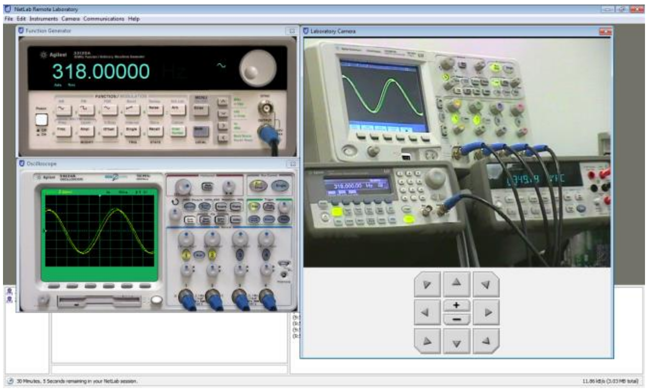

Fig. 8. NetLab GUI with webcam view

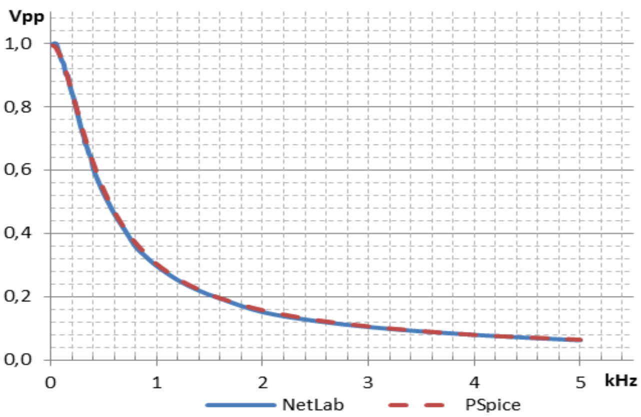

Fig. 9, The graph of the output voltage to frequency for measurements in NetLab and PSpice simulation

In order to verify the accuracy of the measurements, the cut-off frequency was calculated using the formula $f\_c=1/2\pi RC$, and the graph (Fig. 9) outside the curve obtained from measurements has been placed characteristics obtained from the simulation program PSpice. Comparison of simulation results with the results of calculations and experimental results, confirms the correctness of measurements in the NetLab and the proper functioning of the e-lab. The average measurement error in relation to the experimental results was 1.5%.

Conclusion

E-labs allow remote execution of lab exercises with specific fields of science to reflect actual laboratory. Using two modes of operation, we are able to share the actual and the virtual measuring apparatus. In addition, we provide laboratory instructions, check out the student's knowledge before the exercises, to enable the implementation of the report on the basis of measurement results according to a specific formula, and assessing the report.

A big advantage of e-lab NetLab is that exercise can be performed even in the three groups. Students can in one term execute jointly exercise, by connecting to the e-lab from three different locations. A view from a webcam user can observe the results of actual measurement instruments, which adds greater realism to the whole exercise. The camera can be freely set and watch all the elements located in the laboratory.

E-laboratories have become a huge convenience for students with mobility impairments, enabling them to perform most lab exercises without their physical presence at the University.

The deployment of e-laboratories in different parts of the world makes more efficient use of them. Users from other time zones can lead training, when the physical location of e-lab is night time.

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otrzymano/received: 15.06.2016 *przyjęto do druku/accepted: 01.06.2017*