



Tempus

DesIRE



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SUMMER COURSE NITRA

14.-21. September 2014

## Organization team of Summer Course

### 1. Project team DESIRE:

Prof. Ing. Kozík Tomáš, DrSc.

Prof. PhDr. Eva Malá, CSc.

Mgr. Peter Kuna, PhD.

### 2. Lecturers of Summer Course:

Prof. Ing. Kozík Tomáš, DrSc.

Prof. PhDr. Eva Malá, CSc.

Mgr. Miroslav Olvecký, PhD.

Ing. Marek Šimon, PhD.

Ing. Peter Arras, PhD.

Ing. Dirk Van Merode MSc.

Mgr. Juraj Sitáš, PhD.

Ing. Štefan Švarc, PhD.

Mgr. Miroslav Šebo, PhD.

Ing. Roman Čulák

Mgr. Peter Kuna, PhD.

### 3. Realization team of Summer Course:

Prof. Ing. Kozík Tomáš, DrSc.

Prof. PhDr. Eva Malá, CSc.

Prof. PaedDr. Alena Hašková, CSc.

Doc. PaedDr. Viera Tomková, PhD.

Mgr. Miroslav Šebo, PhD.

Mgr. Peter Kuna, PhD.

### 4. Other collaborators:

Pavol Orgler, Imrich Foldeš, Ján Širka, Mgr. Terázia Bagálová, Ing. Tomáš Molnár, Ing. Kultán



# Restructuring embedded systems design engineering-studies towards a practice oriented approach.

Ing. Peter Arras PhD. , Ing. Dirk Van Merode MSc.

## 1. Introduction

Many engineering and science studies in former ex-USSR countries, are based on theoretical knowledge only. The goal of the tempus DESIRE project (Development of Embodied System Courses with implementation of Innovative Virtual approaches for integration of Research, Education and Production in UA, GE, AM) is to adapt current curricula from theoretical based curricula towards a practice oriented based education. Embedded systems design and production demands a very specific, qualitative and valuable knowledge growth in the target higher education institutions (HEI), which ensures efficient implementation of high-skilled people in the labor market. The curricula will be developed according competences needed in local and international labor market. [1]

## 2. DESIRE project aims.

DESIRE is a European funded project in the “Joint Projects-action”. Joint projects are based on multilateral partnerships between HEIs in the EU and the partner countries. The partners can develop, modernize and disseminate new curricula, teaching methods or materials, boost a quality assurance culture, and modernize the management and governance of higher education institutions. The aim of the DESIRE project is to change the theoretical type of learning in embedded systems design engineering in the target countries to a practice-oriented competence-based approach. [2]

The most common form of computer in use today is by far the embedded controller. This controller, combined with embedded software, is referred to as an embedded system (Figure 1). These systems are built into a product for control, monitoring and communication without human intervention. There are some 30 embedded microprocessors per person in developed countries with an average of 250 million lines of code. In a new premium car 20 to 70 electronic control units can be found.



**Figure 1 Typical examples of embedded systems and products containing embedded systems.**

At this moment mainly in all ex-USSR, software engineers are not involved in the science-intensive production, because embedded computer systems are becoming increasingly complex to design and build. The lack of equipment and old educational technologies have resulted in courses in embedded systems being removed from the educational curricula. Main effort at present is attributed to the design of desktop based software, as this doesn't need a lot of investment. It is clear however that such a work can be done cheaper in developing countries. Embedded systems however are used in more critical domains of human life, such as medicine, automotive and aerospace applications. This poses strong demands on quality issues of the embedded hard- and software, so a skilled workforce is necessary to make this a success.

To reach these goals, practice-oriented curricula and modules in Embedded Systems Design are created. The theoretical courses will be supported by remote laboratories and dedicated hardware platforms (physical laboratories) to form the competences necessary for the labor market in Embedded Systems. The practice oriented approach will speed up collaboration between HEIs and business in target countries and ensure the availability of a high-skilled workforce.

### 3. Project DESIRE methodology.

As the aim of the project is to transform existing learning/teaching systems to a Bologna compliant form (competence based, ECTS-supported) the consortium was built to have expertise and know-how on both technical issues as well as on pedagogy. Department of technology of Thomas More university college and the Technische Hochschule Ilmenau joined effort with Constantine the philosopher university in Nitra to bring this project to a successful end.

To come to the expected objectives of the project three different processes are initiated.

The process of making new course material, the process of making a new learning environment and the process of making the new approach operational.

As a first step, the current situation of curricula on ECTS and expected competences (by the stakeholders and labor market) are investigated and reported. This first tasks are performed by the target HEI's (Figure 2) . Next the reported needed competences are turned into curricula, and new course material is developed. The European partners of the project are in charge of this part. With their experiences and know-how on technology (of embedded systems) and pedagogy (of teaching engineers), they propose the new curricula and provide the necessary course materials for this. This material will be translated by the target HEI's in the local teaching language, and if necessary reworked to fit in their (accredited) curricula.



Figure 2 Process for course development.

A next phase will be the establishment of a learning environment (Figure 3 ), containing an LMS, a remote and a embedded systems design laboratory. For this purpose specific equipment is bought to support the courses and to support the laboratories. Equipment includes hard- and software for embedded systems, server computer and remote laboratory hardware. For the LMS-system Moodle will be used.



Figure 3 Process for making the new learning environment

To make the new teaching/learning environment operational, a lot of effort is spend on training teaching staff of the target HEIs (Figure 4). As such, they will have ample experience with the new system before starting to teach their own students. Retraining courses for teaching staff are organized in BE, GE and SK.



Figure 4 Process of making the new approach operational

Trainees of the retraining courses will teach their colleagues when returning to the home universities. Together with master classes in situ, a solid base is established to start with the teaching to the first pilot group of students, and to integrate all in the curricula.

All is done according to a fixed quality assurance plan, assessments on different levels and close contact with other projects. The goal is also to service local enterprises with high-skilled people, so dissemination activities are done towards this group via the university-enterprise contact group (UEGC), and also in media, via the web resources and



seminars. Management of the heterogeneous project objectives and diverse partners is done via an agreed work plan, with sufficient lines of communication and the erection of different working bodies.

## 4. Remote labs.

In the project is provided to install in each partner HEI a remote lab. The remote lab is a visualization of a process (elevator, storage, pick-and-place robot) ( Figure 5 ) which can be controlled either by programming with a micro-controller, by PLC, or by program coding.

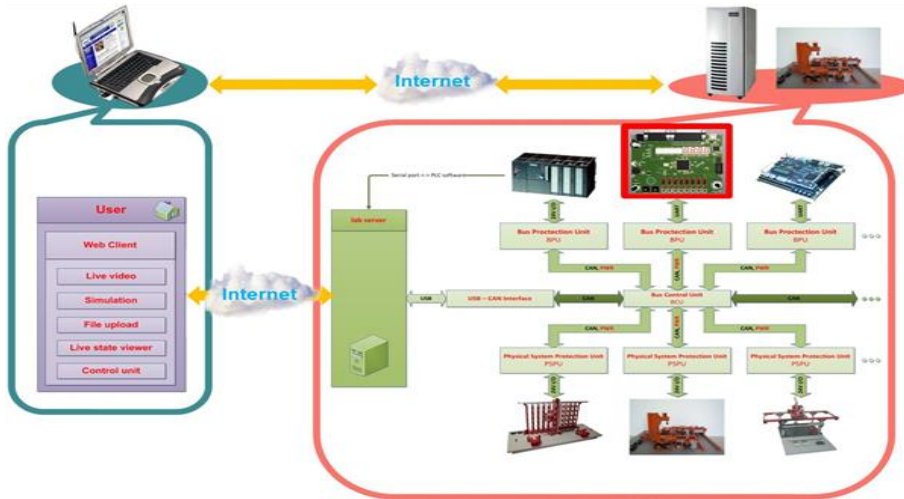


Figure 5 Remote lab setup.

As each HEI will have a remote lab, an extra goal of the project is to make all labs in the different HEIs available for students from all of the consortium. Each HEI will have its own server, so that after the project, each partner is not dependent on a server of the consortium to continue working with the infrastructure. This is very important for the sustainability of the lab infrastructure over a longer period of time, which is one of the most recognized weak points in remote experiments. [3]

Depending on the partner, the aim of working with the remote lab is different.

The technical universities will use the lab as a lab for their students to experiment on. In casu on communication, on programming, on exploitation and security issues. Implementation of the remote lab will only be successful if embedded in an appropriate learning system. A blended learning system as described in (Arras et al) [4] can be an interesting model to promote in the DESIRE-project. As all components are available (physical labs, remote labs, classroom teaching), and the necessary technical know-how in the technical universities is also readily available, this model can be implemented.

The classical universities will use the lab as an example to elaborate new teaching techniques and recommendations for using this kind of remote experiment in pedagogy. The expertise and experience of the western partners will be used as an input for this too.

## 5. Conclusions

The DESIRE-project aims at the transformation of current curricula from theoretical based curricula towards a practice oriented based education. The cooperation of a solid consortium with both technical and classical universities ensures the input of technical know-how and the expertise to transform the educational processes. After completion of the project, the skills and competences of the students in embedded systems engineering will be better in accordance with the demands of industry in the target countries.

After analysis of the current curricula, new curricula and materials will be prepared in accordance to the identified needs of the labor market. Equipment will be bought and installed. An LMS-system will be adapted and courses will be transformed from a traditional classroom teaching to a blended learning approach using the synergy of classroom teaching, physical labs and remote labs to improve skills and competences of students in embedded systems engineering design to comply to labor market demands. In the classical university partner HEIs, future teachers will be trained in exploiting possibilities of remote labs and practice oriented teaching/learning approaches. As such, teaching staff for the next generation has hands-on experience in all of these techniques.

A considerable amount of effort will be put in training teaching staff in the new teaching approaches. Retraining of staff, teach the teacher sessions and pilot teaching will ensure that the method can be adapted. As such the best possible outcomes and sustainability of the project can be ensured.

The effects in the long term perspective will depend on the willingness of all to change to the new approaches. Experiences from the western partners of the consortium at least show that these new practice-oriented approach gives students more opportunities to tune in on the labor market and to be a professional in his/her field.

## 6. References

- [1] S. Beerens, „project DesIRE website,” Thomas More university college, 2014. [Online]. Available: <http://tempus-desire.thomasmore.be>. [Geopend 20 june 2014].
- [2] „Webpage of EACEA, section Tempus Program,” EACEA, last update 2014. [Online]. Available: [http://eacea.ec.europa.eu/tempus/index\\_en.php](http://eacea.ec.europa.eu/tempus/index_en.php). [Geopend 20 june 2014].
- [3] T. Kozik en M. Simon, „Preparing and managing the remote experiment in education.,” in *International Conference ICL IGIP 2012*, Villach, Austria, 2012.
- [4] P. Arras, G. Tabunshchyk, Y. Kolot en B. Tanghe, „Architectural Characteristics and Educational Possibilities of the Remote Laboratory in Materials Properties,” in *2014 11th International Conference on Remote Engineering and Virtual Instrumentation (REV)*, Porto, Portugal, 2014.





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## CONSTANTINE THE PHILOSOPHER UNIVERSITY IN NITRA



Constantine the Philosopher University (UKF) is situated in the city of Nitra, Slovakia. It became a successor of Pedagogic Institute founded in 1959 and Faculty of Education (1964). UKF consists of five faculties:

- Faculty of Arts,
- Faculty of Education,
- Faculty of Natural Sciences,
- Faculty of Social Sciences,
- Faculty of Central European Studies.

Over the course of time, UKF has secured its position in the Slovak higher education system while transforming itself into a university – an advanced educational and research institution meeting the criteria imposed on European university institutions. UKF provides education not only in traditional teacher training but also in many other professional study programmes at three levels of study: bachelor, master and doctoral. About 12 000 full-time and part-time students are enrolled at UKF nowadays. International relations are based on bilateral agreements between UKF and foreign partners as well as on mobility programmes and research and educational projects. UKF is a member of a number of international organizations such as European University Association, Magna Charta Universitatum, Association for Teacher Education in Europe, Eastern European University Network.

**Video about University**

## Department of Technology and Information Technologies

Prof. Ing. Tomáš Kozík, DrSc.,  
Head of the Department of Technology and Information Technologies  
Faculty of Education UKF in Nitra

I have the pleasure to inform the participants of the Summer Course on the profile of the Department of Technology and Information Technologies, Faculty of Education, Constantine the Philosopher University (PF UKF) in Nitra.

For a period of more than 50 years of its existence, the Department has been dynamically developing, and now represents the workplace with modern-oriented educational and research programmes.

They were the results of research and educational work in the Department, which formed the basis of the fact that the Accreditation Commission of the Slovak Republic recognized the rights to carry out educational programmes at all degrees: in the programme of Teaching Vocational Subjects and Practical Training at Bachelor Degree (Bc./BCs), Master Degree (Mgr./MA) and Doctoral Degree (Philosophiae Doctor, PhD.), as well as the undergraduate programme Safety and Health at Work. The Accreditation

Commission also authorized the Department to hold habilitation and inauguration proceedings in the branch Didactics of Technical Professional Subjects

Department of Technology and Information Technologies PF UKF in Nitra is a university workplace providing courses for future teachers of technical subjects in a system of general education of youth in terms of acquiring technological literacy and the right relationship to technology.

Scientific and educational achievements of the Department staff and students were recognized by the professional community at home and abroad, what resulted in:

- Mutual cooperation with departments at Slovak and foreign universities with similar professional and educational orientation.
- Acceptance of the Department by professionals and the public as a scientific and educational workplace with a clear and well-defined scientific school in the field of didactics of technical professional subjects.
- Involvement of the Department representatives in the advisory bodies and committees of the Ministry of Education, their appointment as members of the editorial boards of national and international professional journals, nominations to scientific boards of universities and research boards of national and international conferences and symposia, etc.

Department of Technology and Information Technologies by its activities at university environment and education sector affects changes in the educational system of the Slovak Republic. It highlights issues of the quality of education solutions for different types of schools, curricula updating and modernizing teaching methods. Innovative teaching is based on the development of technical creativity of future teachers, their ability to organize creative activities of pupils/students in technical subjects at primary and secondary school.

Department of Technology and Information Technologies in accordance with that orientation concentrates and conducts its scientific and research activities particularly focused on:

- solving theoretical and practical problems of quality and efficiency of technical education in accordance with the requirements of the information, research of the ICT effect in the professional and practical communication in society,
- research of the conditions of didactically effective use of virtual laboratories in teaching practice,
- analysis of the impact of distance education training centres, centres for lifelong learning of population,
- research in the field of the conditions of legislative measures of health and safety at work in schools and school facilities,
- research of materials and technological properties of engineering materials (plastics, ceramics and glass).

The Department of Technology and Information Technologies, in addition to the direct educational and research work is interested in and supports the student activities that positively affect their personality development and social life during their studies at the university. Among the regular events organized by the Department for students of the Faculty of Education and for primary school pupils and the public belong:

- Student workshop in which students exchange their experiences from activities, which are dealt with in their spare time. Name of the activity "What you know - teach others" reflects the general thrust of the workshop. Students inform on their hobbies not only theoretically, but present practical outputs.
- Student research and professional activity, which is aimed at encouraging those students interested in the research work in the design and unconventional solutions to educational, technical, technological and materials problems. The results of their work are defended before the international expert commissions.
- Technical Olympiad and technical minimum - organized competition for primary school pupils of the Slovak Republic. Their knowledge and skills in technology is demonstrated in the competition in individual competitions at school, regional and national level. Winners receive awards of the Minister of Education.
- Technologies Contest is an international competition of undergraduate and graduate theses organised in Pilsen, Czech Republic.
- As part of lifelong learning, the Department offers opportunities for seniors to study at the University of the Third Age in the study programs: Information Technologies and educational activities of seniors, crafts (pottery, tinkering, wood carving and others), digital photography and production, and other programs, especially those related to information technologies.
- Department is actively engaged in activities that are organized by the University of Constantine the Philosopher in Nitra, and the City itself. These include Nitra Summer University for elementary school pupils, Week of Science and Research, Academic days and others.

Department of Technology and Information Technologies since its establishment has extensive cooperation with foreign partners in the Czech Republic, Hungary, Poland, Germany, England, Ireland, Belgium and other countries.

### Photo-documentation of department activities:



**Open Day for people interested  
in studying**



**Open Day for people interested  
in studying**



**Children's Summer University**



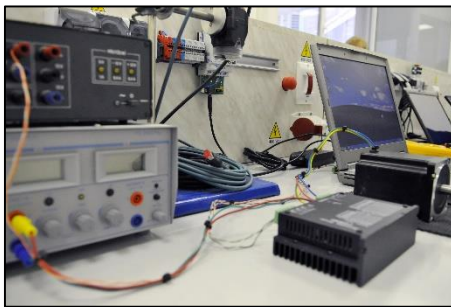
**Open Day for people interested in studying**



**Demonstration of specialized laboratories**



**Demonstration of specialized laboratories**



**Demonstration of specialized laboratories**



**The international exhibition "Young technical creator"**





**The international exhibition  
"Young technical creator"**



**The international exhibition  
"Young technical creator"**



**The international exhibition  
"Young technical creator"**



**International video conference**



**International conference**



**The international scientific  
cooperation**



**The international scientific cooperation**



**Olympics competition for young technicians**



**The international symposium  
"Week of safety and healthy"**



**The international symposium  
"Week of safety and healthy"**



## Summer Course Nitra 14 – 21/09/2014

### 1. Program of Nitra Summer Course

#### Dates of the course:

14 September – 21 September 2014

#### Venue of the course:

Constantine the Philosopher University in Nitra

Faculty of Education

Department of Technology and Information Technologies

Dražovská cesta 4, 949 74 Nitra, Slovakia

#### 14 September 2014, Sunday

Arrival of participants of the Course in Vienna, transfer to Nitra

(registration, accommodation – hotel - dormitory)

19:00 Welcoming all the Course participants at the hotel

#### 15 September 2014, Monday (venue: conference room Hotel Riverside)

Opening of the summer course

9.00: Info on the program

9.15 Lecture: The Bologna Process and European Higher Education Area 12.00-13.00: Lunch at the restaurant Riverside

13.30-16.00: Lecture: E-learning methods in education. (UKF - Department of Technology and Information Technologies, room 112)

#### 16 September 2014, Tuesday (venue: UKF - Department of Technology and Information Technologies)

9.00 – 12.00: Workshop: E-learning methods in Education (room 112 )

12.00 - 13.00: Lunch at UKF cafeteria

13.00 – 13.15: Welcome by DESIRE project Coordinator to the participants of Summer course (room 112)

13.30 – 16.00: Lecture: Information technologies in the Remote experiment

(Informatics minimum for users of remote experiments in LMS)

(room 112)

**17 September 2014, Wednesday (venue: UKF - Department of Technology and Information Technologies)**

9.00-12.00: Workshop: Information technologies in the Remote experiment

(Practical exercises aimed at searching for remote real experiments on the Internet ) (room 112 )

12.00 - 13.00: Lunch at UKF cafeteria

13.00 - 14.00: Lecture: Experience with the use of remote experiments in the University technological education (room 112 )

14.00 – 15.00: Workshop on the use of the course development template (room 112)

16.30 – 19.00: Project Consortium meeting (room 112 )

20.00 Summer course social event and dinner: venue, hotel Riverside

**18 September 2014, Thursday (venue: UKF - Department of Technology and Information Technologies)**

9.00-12.00: Workshop: Working with a particular remote experiment

Presentation of the laboratories of the Department of Technology and Information Technologies: Laboratory of the CNC machining, Laboratory of the PLC systems, specialized classroom aimed to ICT learning. (room no 112)

12.00-13.00: Lunch at UKF cafeteria

13.00 – 14.00: Demonstration Flow Code Buggy (room 112)

14.00 - 15.00: Demonstration of Lego Mindstorms (room 112)

15.00 – 16.00: Discussion with course participants and lecturers on the use of remote labs in education (room 112 )

### **19 September 2014, Friday (venue: UKF - Department of Technology and Information Technologies)**

9.00 – 12.00: Workshop: Interactive forms of learning supported by computer technology (Education of the electro- technical subjects supported by Interactive Method ). (room 112 )

12.00-13.00: Lunch at UKF cafeteria

13.00-15.00: General discussion with the course participants and lecturers on the themes of the summer course (room 112)

15.00- 17.00: Evaluation and closing ceremony of the Course (room 112 )

### **20 September 2014, Saturday**

Guided (bus)tour to the city of Bratislava and its surroundings

### **21 September 2014, Sunday**

Farewell to the Course participants – transfer to Vienna airport.

Departure to the home countries

## 2. List of participants of Summer Course in Nitra 2014

	Name	University	WorkPlace	Position
1.	Mrs. Galyna Tabunshchuk	Zaporizhzhya National Technical University Zhukovskogo 64, 69063 Zaporizhzhya Ukraine	Computer Software Department Faculty of Information Science and Computer Engineering	Associate Professor (Docent)
2.	Mrs. Anzhelika Parkhomenko	Zaporizhzhya National Technical University Zhukovskogo 64, 69063 Zaporizhzhya Ukraine	Computer Software Department Faculty of Information Science and Computer Engineering	Associate Professor (Docent)
3.	Mr. Andriy Parkhomenko	Zaporizhzhya National Technical University Zhukovskogo 64, 69063 Zaporizhzhya Ukraine	Educational-methodical Department	Associate Professor (Docent) Deputy Chief
4.	Mr. Girey Seydametov	Crimean Engineering and Pedagogical University ul. Sevastopolskaya, per. Uchebnii 8 95015 Simferopol Ukraine	Information and Computing Department	Lecturer
5.	Mrs. Zarema Seidametova	Crimean Engineering and Pedagogical University ul. Sevastopolskaya, per. Uchebnii 8 95015 Simferopol Ukraine	Information and Computing Technology Department Faculty of Information	Professor Chair of the Department
6.	Mrs. Susana Sieitveliieva	Crimean Engineering and Pedagogical University ul. Sevastopolskaya, per. Uchebnii 8 95015 Simferopol Ukraine	Information and Computing Technology Department Faculty of Information	Senior Lecturer

7.	Mr. Oleksandr Tarasov	Donbass State Engineering Academy Shkadinova 72, 84313 Kramatorsk Ukraine	Computer and Information Technology Department	Prof DrSc Head of the Department
8.	Mr. Pavlo Sahaida	Donbass State Engineering Academy Shkadinova 72, 84313 Kramatorsk Ukraine	Computer and Information Technology Department	Associate Professor
9.	Mr. Oleg Subotin	Donbass State Engineering Academy Shkadinova 72, 84313 Kramatorsk Ukraine	Automation of Production Processes Department	Associate Professor
10.	Mrs. Nataliia Morze	Borys Grinchenko Kyiv University Vorovskogo Street 18/2, 04053 Kyiv Ukraine		Vice-Rector on Informational Technologies
11.	Mr. Bohdan Hrytseliak	Borys Grinchenko Kyiv University Vorovskogo Street 18/2, 04053 Kyiv Ukraine	IT in Education Laboratory	Deputy Head of IT in Education Laboratory
12.	Mrs. Oksana Buynytska	Borys Grinchenko Kyiv University Vorovskogo Street 18/2, 04053 Kyiv Ukraine	IT in Education Laboratory	Head of IT in Education Laboratory
13.	Mr. Arman Chilingaryan	State Engineering University of Armenia (Polytechnic) Teryan 105, 0009 Yerevan Armenia	Faculty of Cybernetics	Associate Professor
14.	Mr. Nelson Mamulyan	State Engineering University of Armenia (Polytechnic)	Labor Market Research and Professional Career Center	Coordinator of the Center

		Teryan 105, 0009 Yerevan Armenia		
15.	Mr. Taron Hovhannisyan	State Engineering University of Armenia (Polytechnic) Teryan 105, 0009 Yerevan Armenia	Interfaculty Chair of Microelectronic Circuits and Systems	Lecturer/Assistant
16.	Mrs. Gohar Avetisyan	Yerevan State University of Architecture and Construction Teryan 105, 0009 Yerevan Armenia	Chair of ICTMS Faculty of Management and Technologies	Deputy Chairholder of ICTMS Project Coordinator of NUACA
17.	Mr. Azat Smbatyan	Yerevan State University of Architecture and Construction Teryan 105, 0009 Yerevan Armenia	Chair of ICTMS Faculty of Management and Technologies	Lecturer - researcher
18.	Mr. Gevorg Margaryan	Yerevan State University of Architecture and Construction Teryan 105, 0009 Yerevan Armenia	Chair of ICTMS Faculty of Management and Technologies	Lecturer - researcher
19.	Mr. Arkadi Barkhudaryan	Yerevan State University of Architecture and Construction Teryan 105, 0009 Yerevan Armenia	Chair of Hydraulics, Heat and Gas Supply and Ventilation	Assoc. Prof. Vice-rector for Education Affairs
20.	Mrs. Tamar Lominadze	Georgian Technical University	E-Learning Center	Professor Head of the Center



		Kostava street 77, 0175 Tbilisi Georgia		
21.	Mrs. Nino Kikilashvili	Georgian Technical University Kostava street 77, 0175 Tbilisi Georgia		Student
22.	Mrs. Ana Kobiashvili	Georgian Technical University Kostava street 77, 0175 Tbilisi Georgia	Department of Economical Informatics Faculty of Informatics and Control Systems	Professor
23.	Mrs. Ia Mosashvili	Georgian Technical University Kostava street 77, 0175 Tbilisi Georgia	Faculty of Informatics and Control Systems	Associate Professor
24.	Mr. Giorgi Ghvedashvili	Ivane Javakhishvili Tbilisi State University Ilia Chavchavadze Ave. 3, 0179 Tbilisi Georgia	Department of Scientific Research and Development Department of of Electrical and Electronic Engineering Faculty of Exact and Natural Sciences	Professor Head of the Department
25.	Mrs. Tsisana Gavasheli	Ivane Javakhishvili Tbilisi State University Ilia Chavchavadze Ave. 3, 0179 Tbilisi Georgia	Department of Scientific Research and Development Department of of Electrical and Electronic Engineering Faculty of Exact and Natural Sciences	Chief Specialist
26.	Mr. David Kakulia	Ivane Javakhishvili Tbilisi State University Ilia Chavchavadze Ave. 3 0179 Tbilisi Georgia	Department of of Electrical and Electronic Engineering Faculty of Exact and Natural Sciences	Associate Professor



27.	Mr. Mher Markosyan	Yerevan Telecommunication Research Institute CJSC Dzoprapi 26, 0015 Yerevan Armenia		Director of the YeTRI Project Coordinator of the YeTRI
28.	Mrs. Yelena Aramyan	Yerevan Telecommunication Research Institute CJSC Dzoprapi 26, 0015 Yerevan Armenia	Constructor Byuro	R&D Engineer Designer of Constructor Byuro

### 3. Annotations of contributions

**Prof. PhDr. Eva Malá, CSc.**

**Lecture:**

The Bologna Process and European Higher Education Area

**Annotation:**

The lecture is divided into several parts covering the basic data on the Bologna Process and the European Higher Education Area focused on international cooperation and academic mobility of students and staff. The introduction of the three cycle system and the credit transfer system, and the conditions of the recognition of qualifications are briefly explained. A special attention is paid to the standards of internal and external quality assurance of higher education.

**Prof. Ing. Kozík Tomáš, DrSc., Mgr. Miroslav Olvecký, PhD.**

**Lecture:**

E-learning methods in education.

Theoretical aspects in the implementation of VRE through the E-learning methods

**Goal:**

- to acquaint the participants with the e-learning methods in the area of undergraduate study;
- to know the opinions of the participants in the application of e-learning methods in the education;
- to disseminate the mutual knowledge/experiences about e-learning methods;
- to support the positive access to the solving problems with application of the e-learning methods in the area of VRE.

**Annotation:**

Continuous implementation of available modern information and communication technologies to education leads not only to eliminate the shortages of traditional education, but also to efficient and attractive learning process. The teachers try to integrate the latest methods, forms, concepts, teaching aids and didactics technique in the practice. The main purpose of this is to find, design and create the suitable learning environment, which will meet the requirements and needs of labour market.

**Workshop with discussion:**

The experiences with the application of e-learning methods

**Goal:**

- to know the particular phases of lesson;
- to deepen the knowledge of didactical principles and their application in the education;
- to acquaint the participants with the possibilities of application the e-learning methods in the connection of VRE;
- to support the application of this possibilities on the particular workplaces of participants;
- to demonstrate the model of the implementation the suitable e-learning methods and didactical principles in the particular phases of lesson on the example of selected real remote experiment.

**Annotation:**

For many teachers and researchers is important to know not only e-learning methods but also the appropriate didactics principles in the specific phase of lesson to create the suitable learning environment. Blended learning as modern learning tool should offer new possibilities to get necessary results in the education. The model of selected real remote experiment is demonstrated.

**Prof. Ing. Kozík Tomáš, DrSc., Ing Marek Šimon, PhD.**

**Lecture with discussion and workshop:**

Information Technologies in Remote Experiments.

(E-learning course of the informatics minimum for users of remote experiments in LMS)

**Form:**

Lecture with discussion and workshop.

**Goal:**

- to teach participants to use remote experiments in education. At the level of values and attitudes
- to realize how to use the remote experiment in education. At the level of knowledge - understand the basic issues of computer networks and the Internet,
- to know remote experiments and their use in education.
- at the level of work activities and skills - use information and communication technologies for presenting remote experiment.

**Annotation:**

Both activities, the lecture and workshop is composed of three thematic units.  
Internet.

- Principles and concepts of the Internet.
- The components of computer networks.
- Communication protocols.
- Network debugging tools.
- Security aspects of computer networks

- Web browser and Internet search service

Remote Experiment.

- Principles and concepts of remote experiment.
- Types of remote experiments.
- Technology of remote experiments.
- The searching of remote experiments.
- Methodology of remote experiments.

The presentation of remote experiment.

- Applications to create presentations. Presentation of the remote experiment.
- LMS. LMS Moodle.

Practical exercises aimed at searching for remote real experiments on the Internet

## Ing. Dirk Van Merode MSc

### Lecture:

Workshop on the use of the course development template

### Goal:

- To explain the process of conception and integration of an e-learning supported learning and teaching method in the field of material sciences.
- To show the participants a case study of construction and use of a remote laboratory in the area of material sciences for the undergraduate study for engineering.

### Annotation:

To guard uniformity throughout the courses a template has been developed in order to structure and edit the courses. Moreover it will enable participants easy studying, with additional sign posts for recognisability and clearly stated learning outcomes for the course and its containing chapters. Assessments, additional input and additional tasks can easily be added to the course text. An important goal is to provide aides for students with learning difficulties and accessibility for students with learning and other disorders in mind, regarding proper font usage, text being well structured and edited, and graphical support.

### Lecture:

Demonstration Flow Code Buggy

### Goal:

- The participants will get an demonstration on the use and possibilities of the Formule Flowcode robots

### Annotation:

For popularization of technical studies and electronics in particular, students should be in contact with embedded systems in an early stage. The Formula Flowcode robots are developed for that reason. They can be programmed using a graphically method of flow-code diagrams and they can simulate in and outputs in an appealing way.

Afterward the robot can be programmed to see the outcome of the program. On the robot there are some appealing sensors and actuators to make students enthusiastic. Due to ample course material, this learning aid is easy to start off with. But on the other hand, this is a strong starting point for learning to program in the C-language.

**Ing. Peter Arras, PhD.**

**Lecture:**

Experience with the use of remote experiments in the faculty of engineering technology of KU Leuven

**Goal:**

- To get the participants starting with the course template

**Annotation:**

Teaching and laboratory resources are scarce at universities. For the introduction in the content of new topics and technology, therefore new methods need to be found to make more efficient use of available resources in time, personal and infra-structure. The case study presented demonstrates the successful introduction of CALM (Computer Integrated Learning Module), an e-learning supported learning/teaching method in the field of material sciences.

**Prof. Ing. Tomáš Kozík, DrSc., Mgr. Miroslav Šebo, PhD., Ing. Roman Čulák, Mgr. Peter Kuna, PhD., Mgr. Juraj Sitáš, PhD.**

**Lecture:**

Application of remote experiments in education.  
Engineering principles of remote experiments managing.  
Working with a particular remote experiment.

**Goal:**

Technical aspects of construction RL:

- Defining technical requirements for construction systems of RL
- Overview of available control systems of RL.
- Construction of RL by using elements of industrial automation.

Educational and didactic aspects of construction RL:

- Defining pedagogical and didactic requirements for construction systems of RL
- Didactic and pedagogical aspects of the use of VRE in the learning process.

**Annotation:**

Using of remote experiments in education process



**Workshop with discussion:**

Presentation of the laboratories of the Department of Technology and Information Technologies: Laboratory of the CNC machining, Laboratory of the PLC systems, specialized classroom aimed to ICT learning.

**Ing. Štefan Švarc, PhD.**

**Lecture:**

Interactive Forms of Learning Supported by Computer Technology

**Annotation:**

At the workshop the author will focus on the application of interactive teaching supported by voting equipment. The participants will be acquainted with an interactive educational system designed by the author. The main principle of this system is the division of labour between a teacher and his learner which is oriented at maximal (optimal) use of learner's potential. The teacher's activity starting from accepting strategic decisions through producing supported materials and creating a complex system of motivation and evaluation of learner's work and his results conforms to the stated aim. The main objective of applying the educational system in teaching is to motivate learners to discover connections between phenomena and to be interested in acquiring new knowledge. Learners should also enjoy cognition and belief in their own strength. The participants will become familiar with preparation of basic teaching materials (text, picture, table, graph, scheme, etc.), they will learn to formulate questions on the prepared materials and will be able to vote during the workshop.

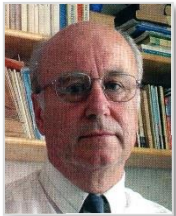
## 4. Characteristics of lecturers

### Ing. Peter Arras, PhD.



**Peter Arras**, Ing., PhD. graduated as engineer in 1985 at De Nayer institute in Belgium. Got a pedagogical degree in 1986. Teaching design methods and numerical simulation methods in the faculty of engineering technology of KULeuven Since 2006 international studies coordinator at the department. Areas of interest in his scientific work are design related methods, CAD/CAM/CAE-systems, e\_learning methods.

### Prof. Ing. Kozík Tomáš, DrSc.



**Tomaš Kozík**, Prof, Ing, DrSc, graduated in physics of solid states from the Slovak University of Technology in Bratislava, Slovakia in 1969. After defending his Doctoral thesis in condensed matter physics he was granted title PhD. In 1989 he defended his DrSc in technology of ceramic materials processing and was appointed associate professor in branch of physics of condensed compounds and acoustics at the Slovak University of Technology in Bratislava and later in 1994 full professor in branch of electrical engineering materials at the Faculty of Electrical Engineering, STU in Bratislava. Since 1990 he has been working at the Department of Technology and information Technologies, University of Constantine the Philosopher in Nitra and as an external professor at the Slovak University of Technology in Bratislava, at the Faculty of Materials Science and Technology in Trnava. His main research activities are focussed on physical properties and technology of the classical and progressive ceramic materials, special glasses and plastics treatment, as well as didactics of technical vocational subjects.

### Prof. PhDr. Eva Malá, CSc.



**Prof. PhDr. Eva Malá, CSc.** has been teaching at the Department of Language Pedagogy and Intercultural Studies, at Faculty of Education, Constantine the Philosopher University in Nitra. As a professor in Technology of Education she supervises doctorate students in the design of e-learning study programmes. She has several years of experience in the participation and elaboration of projects at national and international levels. She has published scientific monographs, academic textbooks and more than a hundred articles. She gives presentations at national and international scientific conferences. She was a chair of the Board of Trustees of SAAIC (Slovak Academic Association for International Cooperation) and the Vice-Rector for International Relations at CPU in Nitra (2006-2010).

### Ing. Dirk Van Merode MSc.



In 2002 **Dirk Van Merode** finished his engineering studies in Electronics to become a Master in Science. His first educational experience was in secondary education in electricity and electronics, to earn his certificated in pedagogical aptitude. Dirk moved to Lessius University College, currently renamed Thomas More University College, in 2007, to take up a teaching assignment and to do research. His field of expertise is in digital systems design, printed circuit board design and production, and audio-video production. Research topics are mainly in European projects, both on curriculum development and student and staff mobility with countries outside the EU. Dirk also did some in-depth research in space applications and satellite development. Currently he is project coordinator of the DESIRE Tempus project, Development of Embedded System Courses with implementation of Innovative Virtual approaches for integration of Research, Education and Production in UA, GE, AM " – 544091-TEMPUS-1-2013-1-BE-TEMPUS-JPCR. For the department electronics – ICT he is the international coordinator.

### Ing. Marek Šimon, PhD.



**Dr. Marek Šimon** received the Ph.D. degrees in Didactics of technical professional subjects from Constantine the Philosopher University, Faculty of education, Slovakia in 2013. He received his Diploma degree in Automation Engineering from the Slovak University of Technology, Slovakia in 1996. Dr. Šimon is currently a Senior Lecturer and Deputy of the Head of the Department of Computer Science at The University of SS. Cyril and Methodius in Trnava, Slovakia. His research interests is primarily in Network Security and Computer Education. He has published lots of academic papers in journals and conference proceedings. Dr. Šimon is an editorial committee member of *Journal of Information Technologies* (ISSN 1337-7469) and *International Journal of Information Processing and Management* (ISSN 2093-4009 /Print/, ISSN 2233-940X /Online/, Scopus).

# Something about remote experiments and Laboratories

## "E-LEARNING ENVIRONMENT FOR THE REMOTE STUDY IN MATERIAL PROPERTIES COURSES"

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**Abstract:** *In this paper a newly developed e-learning environment for the support of the study on Material Properties is presented. It was developed to support the blended learning of the material and shape stiffness. Course structure is organized in HTML content, and virtual and remote laboratories are integrated in the computer aided learning module (CALM), which support both teachers during the hand-on teaching and students during self-study.*

**Keywords:** CALM, remote laboratory; virtual laboratory; material stiffness, shape stiffness.

### 1. INTRODUCTION

The field of material science is defined as a key knowledge area for engineers. Many – if not all – innovations in modern technologies are related to the use of new materials, or new technological methods of using existing materials. However, study time in existing curricula is limited and new findings in material sciences cannot be fitted in. E\_learning modules could help make up for this lack of time. This paper is devoted to the Computer Aided Learning Module (CALM) [1], developed for the supporting e-learning courses in Material Science Properties.

### 2. STRUCTURE OF THE COMPUTER AIDED LEARNING MODULE

A complete driving learning module for material sciences is constructed. The structure of it can found in

fig. 1. It is the framework in which fits the theoretical courses, and the different laboratories described.

The present remote lab in the Computer Aided Learning Module (CALM) is intended to be used to study the phenomenon of material versus shape stiffness. The CALM contains all the learning contents students are supposed to study on the subject. The CALM will be used in classroom teaching and demonstrated to instruct students on how to use the remote lab.

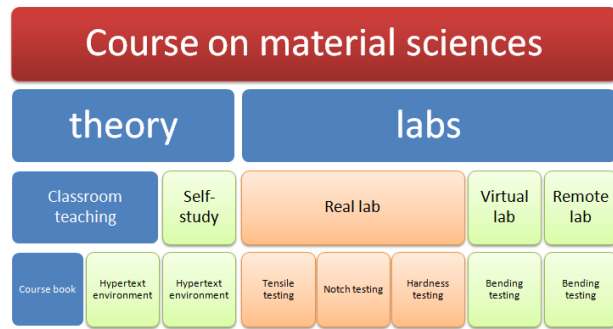


Figure 1. – Structure of the course on material science, integrated in the CALM

Students will study theory afterwards at their own pace, using the hypertext environment, and next simulate different combinations of materials and shapes in the virtual laboratory. Finally students can experiment on real material and shapes in the remote laboratory.

Different techniques are combined: hypertext linked contents, virtual lab (using Shockwave Flash) and a remote lab (controls for it using Javascript) (fig.2). Slideshows are provided for documentation purposes and to include the classroom presentations (fig.3)

The structure of the theory on the CALM reflects the materials in the students physical course books. As such the look and feel of the e\_learning environment is similar to what students experience in the classroom sessions [2].



Figure 2. Navigation in the hypertext

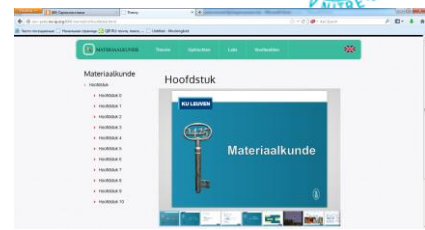


Figure 3. Lectures presentation

### 3. VIRTUAL LABORATORY

The virtual laboratory is a simulation of a test in the physical laboratory for material properties study [2]. It was constructed using the basic formulas for the bending of a cantilever beam. In the virtual lab a number of specimen with standard sections can be tested. Applied force, shape is changeable to offer a wide variety of possibilities. The only limitation with the basic formulas is that asymmetrical test specimens will yield erroneous values, because bending outside the plane of the specimen is not considered in the basic formulas (fig.3).

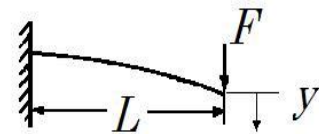


Figure 4. Deflection of a cantilever beam.

Used formulas for bending of a cantilever beam [3]:

Maximum deflection at the free end:

$$y = \frac{F \times L^3}{3 \times E \times I} \quad (1)$$

Maximum bending stress in the cantilever beam (at the supported end):

$$\sigma = \frac{F \times L}{I/v} \quad (2)$$

Moment of inertia (I): e.g. of a rectangle:

$$I = \frac{b \times h^3}{12 \times I} \quad (3)$$

TABLE I. USED SYMBOLS

Used symbols		
Symbol	Name	Unit
E	Young's modulus	MPa
I	Moment of inertia	mm <sup>4</sup>
F	Load	N
$\sigma$	Maximum bending stress in the cross-section	MPa

y	Maximum deflection	mm
L	Length of beam	mm
v	Distance to neutral fiber	mm

#### A. Functional requirements for the virtual lab:

1. Calculation and visualization of the deflection of a cantilever beam, with measurement of deflection at the end and indication of maximum stress and force.

2. The values for different Young's modulus for a variety of materials should be chosen according to reported values [3] .

3. For a variety of shapes (rectangular section, H-beams, U-beam, hollow shapes...) the shape stiffness can be used.

4. For different orientations of the same shape (increment angles  $1^\circ$ ) about the principal axes.

5. For a variety of dimensions in the same shape. (cross section dimensions and length). The different values should be entered by the student experimenter.

#### B. Supplementary Requirements for the virtual lab.

Experimenting students should be able to select all different possibilities with the aid of pull down menus and selection panels, and dialogue boxes for dimensions.

Readings of deflection, force and stresses with the aid of lookalike analogue meters.

Force should be applicable with the aid of a slider bar, and real time adjustment of readings should be taken care of.

Readings should be exportable: available in a window from which to copy, together with material and cross section data. This feature is necessary for the students to make their reports. As such they can copy the data without retyping, but also without any special formatting in the virtual lab, so it can be fit in any report.

#### C. Virtual Laboratory Realisation

For the virtual lab realisation were used HTML5, ActionScript and JavaScript. The component diagram of developed application is presented on the fig 5.

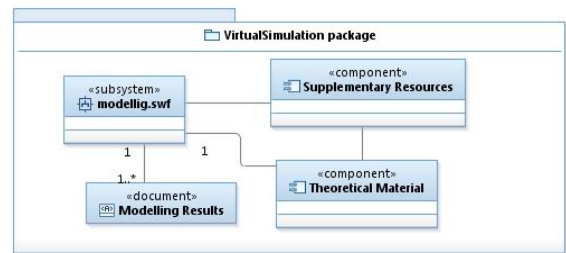


Figure 5. — Component Diagram for Virtual Lab

Subsystem “Modelling” is an interactive animation, based on Flash and ActionScript. Its consists of 3 components: a visual component, a component for calculations and the component showing different shapes. Such realizations make it possible to easily add new shapes.

The realization of the calculation for different shapes is realized by classes put in package beam, which is part of subsystem “modelling” shown on the fig. 6.

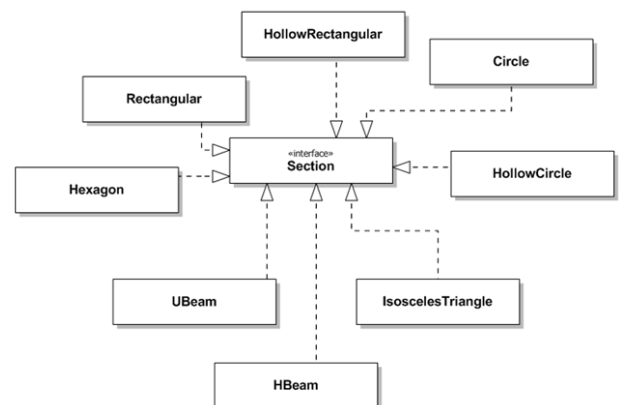


Figure 6. — Class Diagram for the cantilever beam calculation depending from the shape

#### C. Virtual laboratory functionality

To run the experiment on the client side user should use any web-browser with an installed Flash Player. The main screen of the virtual lab is in figure 7.



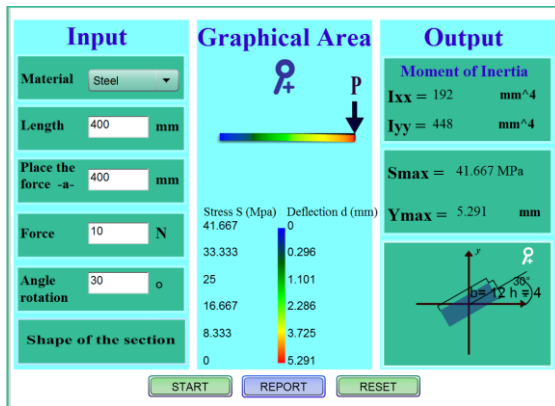


Figure 7. — Screen shot of the actual virtual lab.

All results can be viewed in an additional window and printed (fig. 8). The report window is a simple text window which allows the student/experimenter to copy paste these results in his lab reports, without having to type all texts.

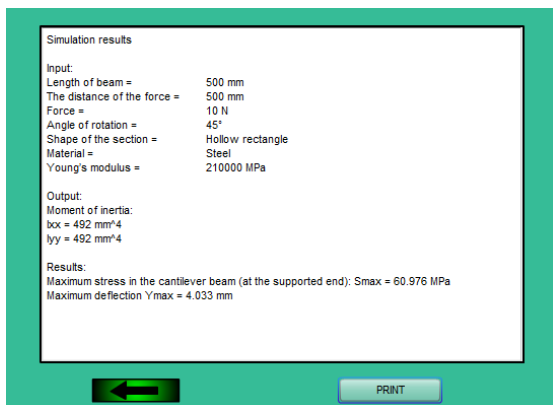


Figure 8. Screen shot of the report screen.

#### 4. REMOTE LABORATORY

The objective of the experiment in the remote lab is similar to the objectives of the real physical lab on bending. First objective is to see and to measure the deflection of the cantilever beams. These values can be compared to the theoretical results from the virtual laboratory. Second goal of the physical lab which is substituted by the remote lab is to let students understand the influence of errors in measuring values on the uncertainty of their results. Students need to calculate the (possible) error on their values by means of the theory of errors, considering all sources of errors in the experiment (accuracy of tools, uncertainty of loads, distances...)

##### A. Hardware construction

The construction of the experiment consist of sets of beams. The beams can be any basic shape (round, square, rectangular, hollow). The beams as deformed by pulling them with pneumatic cylinders (fig.9). A reading scale is attached at the front end to measure the deflection by means of a camera. The reading scale resolution is 1 mm. The improve the read-out of the deflection, at the end of each beam, a blue marker was attached, to contrast as much as possible with the reading scale. Electronic control of the lab is with a simple relay board, on the USB-port of the computer.

In the lab uses an IP-cam for the measurement (reading the scale) and a web-cam for board control and monitoring the deflection.

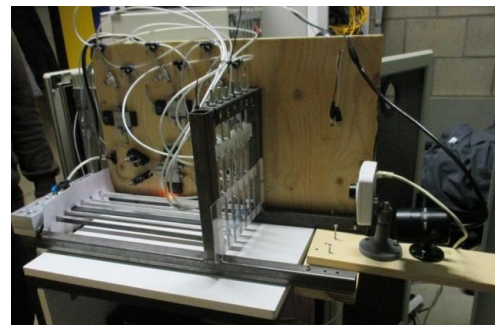


Figure 9. The hardware construction

##### B. Remote Laboratory realization

The control software driving the remote lab and integrating it in the CALM-website was developed with the collaboration with ZNTU, leading to a graphical user interface containing camera pictures and controls in one screen.

In general the software for the remote lab consists of three main subsystems:

- for control of the cameras;
- for board control;
- for lab control;

The subsystem for lab control is a controller which allows to control the process: initiate the session,

safety control, process the logic of the experiment, close the session (fig.10).

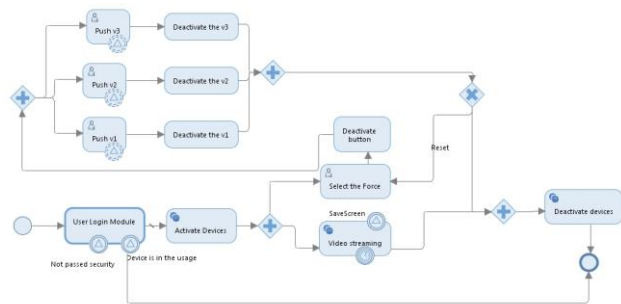


Figure 10. Remote Laboratory functionality

The subsystem for board control task is for switching the relays on the relay board.

In figure 11 is shown the class diagram for these two subsystems.

The subsystem for camera control is an independent system, which allows to output video-streams using the rtsp-protocol and to save screenshots of the device with high resolution for further measurements. Using the rtsp-protocol allows to display the video in browser after installing the vlc-plugin.

For the realization was chosen the Spring MVC Framework. The basic logic was realized with java, for visualization were used HTML, CSS, Javascript, JQuery, JSP.

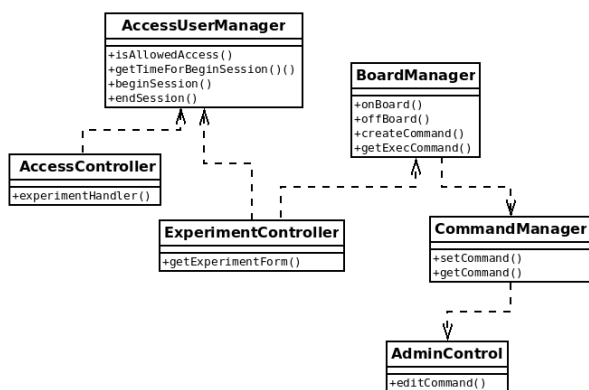


Figure 11. Class diagram

### C. Functionality of lab-control module

After getting access to the remote lab student can choose the force applied to the beams and activate the forces on the different test specimen (beams) by pressing the different valve buttons.

To cope with possible problems on images and video, a section for saving screenshots was integrated for offline working with the experimental results. The different screenshots can be reviewed to measure the deflection at the end of the beams. As such experimenting time could be reduced to 10 minutes per student. Security measures are installed to avoid automated/hacked control of the lab.

The view of remote laboratory control through web interface can be seen in figure 12.

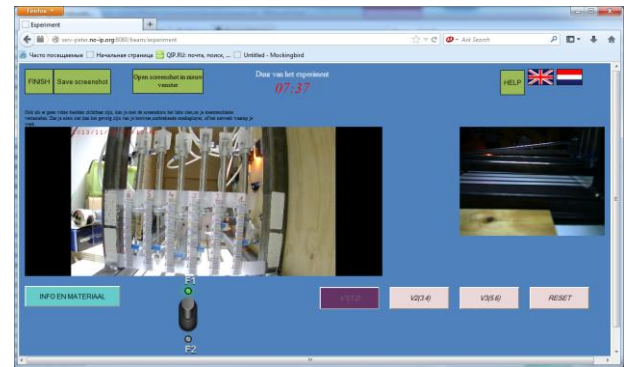


Figure 12. Remote Laboratory: left IP-cam for measuring, right webcam for viewing the deflection.

First evaluations of the lab show that overall functionality of the lab is appreciated by the students. Most of the problems arise with the video (speed of connection for live-streams) and the interference or no connection with plug-ins. Also the use of the lab in different browsers (Internet Explorer, Google Chrome, Firefox) show causes of ineffectiveness as all 3 browsers treat videos differently. This makes it somewhat difficult for the students, as they (sometimes) need to tune their browser first.

## 5. CONCLUSION

The blended learning approach shows the most efficient results among different approaches with the usage of e-learning systems. The developed e-learning environment CALM is useful both for students needs (self-study needs) as for teachers (central source of all course related materials). It consists of different e-

learning tools – html content of learning material as theoretical background and recommendations for practical tasks, tools for lecture presentation, elements of experiments with material properties simulation and remote laboratory, which give possibilities for a more practical approach to learning.

In future, new tasks on expanding the CALM are to modify the architecture to incorporate new infrastructure for other remote laboratories and to enhance the security model, as there are plans to increase number of students using the remote labs. Security is necessary to ensure the safety of the equipment and to avoid early wear or destruction by unwanted use of the remote labs.

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## REMOTE EXPERIMENT IN TERMS OF VIEW OF DIDACTICS OF EDUCATION

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**Abstract:** The preparation and use of remote experiments in the education system consists of the solutions of two, at first glance, single and independent issues. The first one, on the part of the provider - the administrator of the remote real experiment, is a solution of technical design for the remote experiment and consequently its implementation. The second one, on the part of the remote experiment user, is a solution of the tasks related to didactics of the application of remote experiment in the different stages of a lesson. To achieve a positive educational effect from the application of remote experiments in education, solution of didactic tasks is as important as solution of technical design of the experiment. The authors in this paper propose a procedure for making solutions, implementation and operation of remote experiments. They come to the conclusion according to which maintaining the long-term functionality and regular innovation of the remote experiment has the nature of the development spiral. They define the essential role of pedagogical research in relation to the application of remote experiments in education. In addition, they refer two examples of technical solution of remote experiments, in which for the control and management, the programmable logic controller (PLC) is used.

**Keywords:** Remote experiments; Internet; School experiments; didactics

### INTRODUCTION

Real experiments (RE) in natural and technical sciences are integral and inseparable parts of the teaching process. Their fundamental educational aim is to provide a widening of knowledge in the frame of particular topics of the curriculum. The most frequently used method is the verification of the existing laws and dependences between physical quantities or technological parameters. By performing experimental measurements pupils or students:

- obtain the ability to apply theoretical knowledge in the frame of practical activities,
- improve their practical skills with aids and measuring apparatuses,

- gain laboratory experience,
- confirm and widen their knowledge from the course of previous study.

Laboratory experiments cause interaction between previously obtained knowledge and newly gained experience and so they support what we call a metacognition [2] while hand in hand pupils/students learn to cognize methodology of scientific and research work. They also positively influence our youth in the process of their deciding regarding future professional orientation in the area of natural scientific or technical spheres.

Besides educational influence, practical school experiments also have the edifying function. Thanks to them students improve their:

- relationship towards purposeful research and technical work,
- habits in precise execution of work activities,
- sense of fulfillment after successful experiment,
- cognition of the mutual relation between abstract theoretical thinking and practical activities,
- experience in work in the laboratory and in the team.

Progress in the area of Information and Communication Technologies (ICT) changes the environment of laboratories, their technological configuration, methodology of measurements, the way of recording and evaluation of the obtained data. ICT have become a tool that provides conditions enabling the transfer of real experiments from the real laboratory to any place on the Earth via the Internet. Usage of school experiments enables teachers to perform educational activities while emphasizing individual demands [5]. According to the authors [9], usage of the remote experiments enables higher flexibility that is required in the experiments with real phenomena; and above all, the Internet on-line laboratories enable more effective deployment of the laboratory equipment by students themselves, since thanks to the Internet they can use them from any place and at any time. Such sharing of the created laboratory experiments decreases expenditure needed for building and running the laboratories and on the other side it increases accessibility of the experiments for a higher number of students. Nowadays, it is possible to connect more e-laboratories via the Internet that are placed especially in the university workplaces.

### STARTING POINTS OF THE REMOTE EXPERIMENT APPLICATION IN EDUCATION

The creation of a real remote experiment that fulfills demands for its reliable and safe running while meeting methodical objectives is not a simple task. The challenge and specification of this task requires a close cooperation of real experts – specialists. (fig.1)

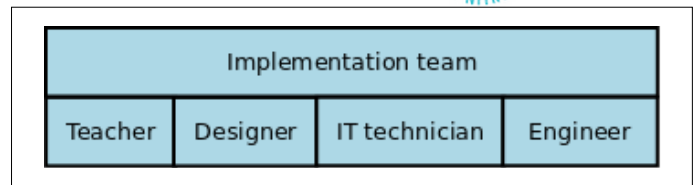


Figure 1. Implementation team of experts

So that real remote experiments can become an effective teaching aid it is important and needed to keep the valid principles regarding the preparation and running of the remote experiment as may be seen in the developmental spiral (fig.2).

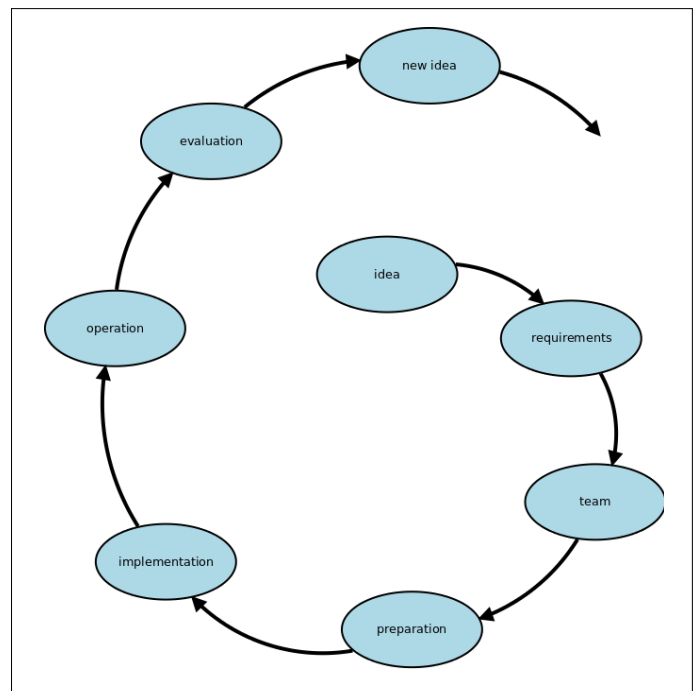


Figure 2. Developmental spiral of remote experiment

The basic idea comes from a designer – a pedagogue, who specifies a task for the experiment from the particular topic of a curriculum, defines fundamental demands for the creation and running of the experiment from both technological and didactical points of view. Last but not least there is a task regarding the creation of an appropriate work team. The outcome of the cooperation of such a team is the created experiment ready to be verified and consequently offered to users on the Internet. Another important phase in the process of further development of the experiment is the evaluation of its functioning that is closely connected to the design of innovative ideas and their implementation in the next developmental cycle.

To provide a sustainable remote experiment we need to guarantee both its sufficient maintenance and continual



innovations where demands from the side of users who in practice are teachers and pupils/students must be taken into consideration.

The crucial demand of teachers regarding remote experiments (RE) is to provide a higher level of fulfillment of educational and edifying aims in teaching process.[7]

The design and application of a remote experiment represent two separate troublesome areas. The first one deals with a technical solution and the running of a remote experiment on the side of a provider who is responsible for the:

- design and construction of a remote experiment on a specific theme,
- system of management and control of functionality of particular experiments,
- philosophy of collecting and processing of the observed data,
- hardware and software support of the remote experiment via the Internet.

On the side of a user of a remote experiment the situation is completely different. The most likely, user of the RE is a pedagogue – teacher, who decided to use the RE as an innovative tool in the lessons. Such a user is primarily interested in the didactic side of the experimental topic and how the experiment can help him/her improve the level of education. Technical and programming issues of the RE are usually just secondary from the point of view of users – teachers.

When working with RE we deal with real laboratory equipment that is perceived indirectly on the side of a user. According to [8] one part of students do not perceive remote laboratories as the real ones and that is why we should try to reach the state where the display and controlling of the experiments are as authentic as possible. It must enable accessibility to all the possible settings of the experiment. Possible faults in the setting of incoming parameters of the experiment cannot be filtered out automatically, but the users must detect them and consequently try to correct them. Outcomes of the measurements should be obtained in the same way as if students take them in direct work with real equipment. [4]

## **SOCIAL CONDITIONS OF APPLICATION OF INNOVATIVE TEACHING SUPPORTED BY REMOTE EXPERIMENT**

In the last 20 years there is an obvious decrement in the interest in study of natural scientific and technical disciplines among students of elementary and secondary schools in the SR. Experience of the authors from numerous study stays abroad show that there is similar development visible also in other European countries. It is generally known that subjects like mathematics, physics or chemistry are not very much preferred and favorite among pupils/students at elementary/secondary schools. A really sad fact is that similar opinions are heard also from the graduates and postgraduates of technical universities.

Successful study of these subjects is generally contingent on the adequate level of abstract thinking, and good spatial visualization connected with logical and analytical thinking. These attributes are not automatically given to all people and even among those who have such skills it is needed to intentionally develop and improve them through the educational process.

Thanks to information technologies much scientific knowledge is accessible to wide layers of inhabitants in the early decades of the 21. century. E-technologies and their continual applications seriously influence traditional educational systems. It is a contemporary issue for the pedagogical staff to answer the questions what to teach, how to teach it and when. The philosophy of education itself changes constantly. There is a tendency to divert from the philosophy of education orientated towards a lifelong occupation and consequently the philosophy of education for constantly changing conditions on the Labour Market comes forward.

What we know is that lifelong education is being emphasized more and more in today's world. Our society starts to realize the meaning and importance of real fulfillment of a term knowledge society or so called learning society in relation to its permanently sustainable development [6].

In the abovementioned social-economic environment there are also educational systems of particular countries whose fundamental aim should be the provision of such an educational level of inhabitants that

has a potential to create preconditions of its future development.

Specification of teaching technical branches is in the necessity of applying a whole range of creative methods for every particular technical or technological problem. This approach in education represents the very substance of innovative educational forms in which a teacher is in the position of a partner for pupils/students and at the same time he represents a role of authority and personage. The basic role of a teacher in this model of the educational process lies in the activation of learners towards the subject of education thanks to which a needed place for individual activities of learners will be created orientated on the already mentioned attributes (abstract thinking, spatial imagination, logical thinking etc.).

In the history of the development of human societies there had never been recorded such a huge acceleration of updating knowledge as it was in the 20. and at the beginning of 21. century. As a consequence of quick mass widening of the ICT applications, new information regarding advances in science, research and social development have become easily accessible for people practically of all social groups. E-technologies are more and more frequently used in the area of education. Step by step the whole society gets to know the meaning and content of the term knowledge society in connection to the perspective of sustainable industrial growth [6].

In the abovementioned social environment there are acting and developing various educational systems. Specification of teaching technical specializations lies in preferential implementation of creative methods in the process of solving various tasks or problems. Getting familiar with this approach from the very beginning (ideally already at the level of pre-school education) creates positive predispositions for further successful understanding of more complicated technical principles in the course of further study and the elegant mastering of various technically orientated activities in everyday life.

### REMOTE EXPERIMENTS AND THE DIDACTIC CYCLE

The creative approach is the substance of an innovative form of education where a teacher stands in the position of a partner while keeping his authority. So that a pedagogue/teacher can reach the required educational

aim, he must be able to attract the attention of learners to the particular topic. And the implementation of experiments (hands-on, remote, simulated) in education is the mean that enables it [11].

In both vocational and pedagogical literature there is no straightforward answer to the question regarding minimal ICT competencies of a pedagogue for the creative application of remote experiments in the teaching process that would enable one to design and create one's own educational experiments while being supported by e-technologies. There is also one reasoned definition of didactic demands for this type of experiments missing, which should be taken into consideration in the process of their design, construction and running. The teaching process has got its specific attested sequence of activities on the side of a teacher as well as on the side of a learner that have been proven in the course of time. This didactic cycle consists of the [12]:

- formulation of the aims of teaching process and consequently their acquisition by learners,
- reiteration of previously obtained knowledge that is closely connected to the new study content,
- exposition and acquisition of a new study content,
- consolidation of newly received information,
- check of the attained outcomes in the educational process,
- setting tasks for a home preparation.

In every one of these phases a teacher can use different methods [10]:

- motivational (supporting interest in learning),
- expository (getting acquainted with the new study content),
- fixative (reiteration and consolidation of information),
- diagnostic and classificatory (examination and evaluation).

Teaching supported by information technologies has recently become a favourite way of teaching among

pedagogues galore and it is positively accepted by students themselves [11][3][2]. This fact itself supports expectation for reaching better educational effect when compared to the traditional forms of education.

If we take into consideration all the mentioned didactic demands in the process of designing and running RE, then such a system should fulfill the following criteria:

- easy accessibility on the Internet,
- simple orientation on the web site of the experiment,
- easily understandable guide regarding handling the experiment,
- assignment with clear definition of educational aims,
- corresponding theory to the theme of an experiment at the appropriate educational level of a user,
- definition of a way of communication between users and provider of the experiment,
- recommendations for pedagogues regarding the deployment of the experiment in particular stages of a teaching unit (in didactic cycle).

From a technical point of view the experiments should be constructed in such way so that:

- the created experiment is in accordance with theoretical knowledge which it is based upon,
- it is technically resistant against user's failure in the process of control of the experiment.

It is obvious that the deployment of a gradually widening net of e-laboratories that are used in pedagogical practice is going to be the subject of serious pedagogical research in the nearest future. The issue of development of new universal systems in management and control of remote laboratories that would provide safety and needed economy in the process of their running shall also be one of the topics of the research.

### TECHNICAL SOLUTION OF REMOTE EXPERIMENTS WITH DEPLOYMENT OF PLC

Authors in the process of designing remote experiments and constructing remote laboratories have decided for the philosophy of applying the elements of industrial

automation. In the process of searching for suitable technical solutions to managing and handling the experiments in remote laboratories they decided to try to use technical parameters and attributes of PLC. PLC (Programmable Logic Controllers) are used in solutions of automatized tasks at different levels of technical difficulty. When deciding about deployment of PLC, the fundamental and original idea was the creation of a universal system of handling and managing. A system constructed in such way will be exploitable also in teaching the subjects orientated on automation.

The system of remote administration of PLC on the Internet is provided via web server which represents the graphical interface (GUI) between PLC and users. Communication between the web application and PLC itself is provided via OPC server (OLE for Process Control).

In technical experimental tasks from the area of electro engineering we frequently may see a task regarding regulation of revolutions of an electric engine. The authors have decided to use the frequency transducer in their remote experiment. In fig.3 is displayed overall configuration of the remote experiment for the regulation of revolutions of the 3-phase electric engine by the 3-phase frequency changer.

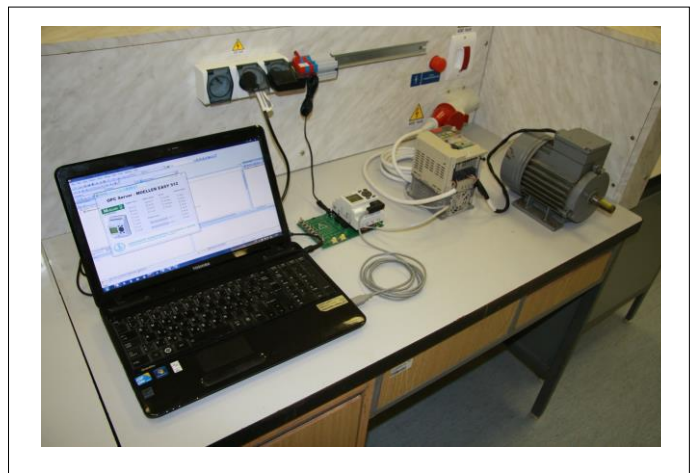


Figure 3. Configuration of the real experiment regarding regulation of the engine revolutions by a frequency changer

Parameters of the frequency changer are set in a way so that revolutions of the engine can be regulated by a time width of the input impulse. It means that if there is a logical 1 at the A master input of the frequency changer, then the speed of the engine will continuously rise all the time while the logical 1 remains active at this input. B input will react similarly in relation to the decrement of



revolutions. In the case that at both inputs (A, B) are logical 0 or 1, revolutions of the engine will not change. In this configuration the PLC made by EATON EASY 512 was used. It is the bitwise combinative automaton managed through OPC server.

In the process of constructing remote experiments in remote laboratories the question of their economic efficiency becomes more and more important. Running the experiments in the remote laboratories is a difficult task from the point of view of the illumination of the workplace. It is required to provide a permanent source of illumination of particular experimental configurations even in such cases when there is nobody logged in on the server.

An interesting decrement in operating expenses can be obtained through the installation of a system that after user's entry turns the light in the laboratory on and consequently activates particular experimental components. This function can be added into the remote experiment that is operated by programmable logical automaton [13].

A model of a remote experiment simulating the abovementioned processes may be seen in the fig4.



Figure 4. Model of regulation of illumination of the remote experiment in the real laboratory

Nowadays, it is not a problem to create practically any experimental configuration and consequently to make it accessible for users via the Internet. Still one open problem remains - how the experiment from the point of

view of a user can be deployed in education, or in other words, how it will be implemented into the teaching unit so that a teacher can reach the demanded educational goals.

## CONCLUSION

Already nowadays there are obviously visible changes in the educational environment at practically all types and levels of schools as a consequence of implementation of up-to-date applications of the information technologies in education. RE make a good example of their penetration into the teaching process especially in natural scientific and technical areas where there is an emphasis put on the deployment of methods regarding the work with experiments. In parallel, they are a challenge for pedagogical research in the area of searching for the answers to the questions regarding their implementation into the teaching process and the impact on knowledge level and specific skills of postgraduates from natural scientific and technical fields. The already published outcomes regarding deployment of the RE in educational sphere point at their benefit especially in the area of shortening the time needed for practical vocational training of pupils/students. We want to state that deployment of RE in education does not automatically mean total exclusion of real experiments from the teaching practice. Ideally, the RE should be combined with the real experiments [11]. The potential of deployment of remote experiments lies in the individual approach of every teacher, their ability to prepare a good experiment and the overall pedagogical mastership considering innovative principles of teaching and the effective exploitation of educational time.

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## REMOTE EXPERIMENT USING ELEMENTS OF INDUSTRIAL AUTOMATION

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**Abstract:** A new concept of solution for control of remote real experiments (RRE) is designed in this work. The designed concept is based on the use of elements of industrial automation at the construction of the RRE. Their use in applications of design of the RRE brings substantial technical and economic benefits in comparison to the previously used systems. A relevancy of the used concept for designing of the RRE in education has been proved by the successful application of the elements of industrial automation in the particular RRE "Measurements of fluid flow" created by the Department of Technology and Information Technology at Faculty of Education, Constantine the Philosopher University in Nitra.

**Key words:** experiment, remote control experiment, PLC system, industrial automation, construction system

### INTRODUCTION

By the progressive expansion of internet services and by the progress made in the field of automation and control technology the remote control/real experiments (RCE/RRE) have been gaining in popularity not only in university education but in the other types of schools – as elementary and grammar schools. The extension of the RRE applications is caused by looking for the teacher's answers: WHAT, WHEN and HOW to teach?

Advances in science and technology and the resulting new unconventional technical solutions together with development of informational technologies create an environment in education which necessarily requires a change in the educational contents and in the forms of education. It is expected that the newest knowledge of science and technology and also more information will be smoothly available for a human during his whole active life due to the development of information technology and other scientific and technical progress. In the educational system there is allowance for an exchange of requested knowledge and abilities for everyone in lifelong learning.

There has been occurred a task for teaching science and professionals working in education how to solve education at this level of development of scientific and technical knowledge and at the requirements of the society. Furthermore, a very important requirement is to propose a solution with signs of economic approach.

Situation in technical and natural sciences is even more complicated due to formation of practical skills and experience during preparation for the profession which is essential part of the preparation and of the education of future specialists. It is very costly to build laboratories and technically complicated workplaces as well as their run and innovation.

One of the possible solutions how to reach the requested quality in education of technical and natural branches (subjects) in connection with the gaining of practical skills when working with measurement equipment and systems is an application of RRE in education.

Thanks to the internet there is a network of the remote real laboratories where the experiments are installed with the possibility of remote control by computing. An ambition of the Department of Technology and

Information Technology at Faculty of Education, Constantine the Philosopher University in Nitra is an active entrance into the global network of existing remote laboratories by creating own remote laboratory complying with exacting technical and educational parameters.

The aim of this work is to show the authors' approach to engineering solution of the RRE, measurement of fluid flow, by using elements of industrial automation.

### REMOTE CONTROL EXPERIMENTS - RCE

The experiment is defined as the basic method of scientific knowledge. It serves to obtaining or testing of new theoretical results. However, the experiment is not a domain for scientists and specialized scientific institutions only. The experiment is applied as one of the teaching methods in teaching practice. This type of experiment differs from the original scientific experiment in its requirements and objectives. Pupil or student will understand an experiment only if he makes it by himself. Therefore it is important that every pupil/student participates actively in control and evaluation of an experiment. The ideal solution would be to make several identical experiments in parallel in groups. Pupils/students would have more space for personal practice in the implementation and control of the experiment. At the same time pupils/students could compare the achieved results to each other and analyze them. It is well known that the school instrumentation for realization of experiments is often insufficient. Studies in the field of educational research show (e.g. results of educational research by Thorton [1]) a didactic suitability of demonstration of the natural science and technical effects and principles in teaching. At such a teaching the pupils/students better understand the link between theory and practice. Science achievements are directly related to observing and studying of events in nature. From this point of view the experiment becomes an important teaching and learning tool. Currently pupils/students of many schools do not have any possibility to confront their theoretical knowledge with practice. A large range of science lesson's theory leads students to memorize the learning knowledge. (The authors reached this conclusion on the basis of

discussions with teachers of primary schools at workshops). This approach does not allow pupils / students adequately understand the discussed topic. The result is an inability of pupils / students to apply the acquired theoretical knowledge in practice. Under the influence of this approach, pupils / students take a negative attitude to the subject which results in a reduced interest of pupils/students in the study of natural science and technical subjects. Currently it is showed a significant reduction in a number of students of natural science and technical subjects what is perceived as a result of the longtime school practice. [2],[3],[4],[5]

One of the possibilities how to solve the current situation in the teaching of science and technology in relation to the use of experiments is the use of remote control experiments. Remote control experiment (RCE) is a real physical, chemical and technical experiment which is realized in a real laboratory. The difference from „classical“ real experiment is that an observer and an executor of the experiment is out of the laboratory and whole running of the experiment is controlled and monitored through the commands and image transmission via a computer network Internet. The design of this type of experiment requires much more time, personnel and financial costs in comparison with the classical real experiments. It is necessary to realize that such an experiment, which is installed in one of the educational workplaces (laboratories) via the Internet, can be used by Slovak, whether European or global electronic network. Accessing of the RCE in a global scale can help to sort out a problem of financial unavailability of experiments in schools of all types. [6]

The results of research of the examination of the application of the executed RCE in teaching and their influence on education level show that the use of the remote control experiments clearly improves quality and efficiency in teaching of science and technology. Thorton research [1], which aimed to compare the success of teaching with the support of the RCE to the classical teaching without experiment showed much better results of the teaching with the support of the RCE. According to research results:

- 30% of the respondents were successful at the use of the classical teaching method, it means teaching method without experiment and
- even 90% of the respondents were successful at the use of the teaching method with the support of the RCE bolo.

Score in favor of the teaching with the RCE use was even more significant in understanding of physical effects and principles. The subject of the study with the use of demonstration of the RCE was understood by up to 90% of pupils/students (respondents) in comparison to 15% of the respondents educated by traditional way without experiment. According to Thorton the high efficiency of the RCE is achieved thanks to the following factors:

- the RCE has a positive influence on an activity of the students,
- independent work of pupils/students on the research technique,
- immediate feedback,
- reduction of the time need for theoretical calculations in relation to deepening the knowledge of students

[1],[7],[8]

### STRUCTURE OF THE RCE

The idea of remote control and monitoring of remote experiment brings special technical requirements for the methods and technical means. In terms of technical requirements of the implementation the technical means of the RCE can be divided into the following groups:

#### a) Technical means carrying out the very natural principle of the experiment

Technical means carrying out the natural or technical principle of the experiment are all the components of the content essence of the experiment itself. These components are often completely identical, whether it is a real implemented experiment or remote control experiment. In this category in case of the RCE (experiment of measuring of fluid flow) there are following components represented: three-phase motor,

fan, flow tube, Venturi or Pittot (Prandtl) tube and plastic tubes.

#### b) Measuring device of physical quantities

This group of components is created by all the measuring device of physical quantities which are involved in the measurement. In case of the remote control experiment there is necessary a measuring device which is equipped with communication ports for sending out the value of measured physical quantity into the control system of the remote experiment.

#### c) Technical means providing remote control of the experiment

Technical means are a specific group providing remote control of the experiment. Here we include all the hardware and software systems which provide for control of the RCE, communication with user, sensing and processing of measured values and also for software control algorithm throughout experiment.

#### d) Devices for scanning and transmission of a video stream

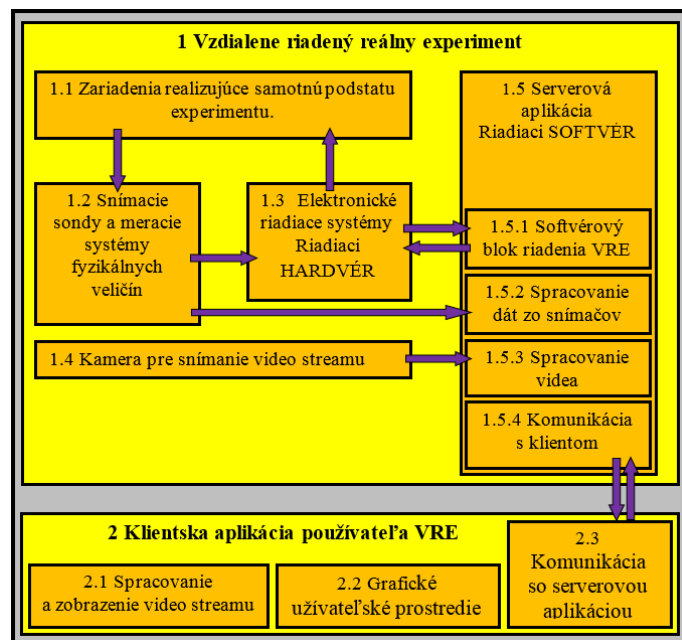
Success of the RCE in teaching practice depends on the quality and speed of transmission of the video stream which provides a general view of experiment course for the user. Transmission of poor and low quality of the video stream can be a key reason for their absence in teaching process. Also in case of excellent technical structure or didactic support the use of the RCE by teacher or by users (pupils/students) can be refused because of the poor video stream. From this reason it is necessary to pay a close attention for this group of devices at the preparation of the RCE.

### BLOCK DIAGRAM OF THE RCE

The RCE shown in the block diagram (pic. 1) is divided into two basic parts. The first part is the experiment itself which is controlled by the user, client over the Internet by the client application. To explain the function of each part of the block diagram we are presenting an illustrative example of the start of measuring evoked by the user. The user presses the START button in his graphical user interface /2.2/. Client application /2/



evaluates the request and through the communication block /2.3/ sends data via computer network of a server application. The server application /1.5/ receives data about client's requirement using the communication block. /1.5.4/



Picture 1: Block diagram of the RCE

The entered information is evaluated (e.g. if the requirement is valid or if its realization is not implemented under the previous command, etc.), after that it is prepared and it is sending a command in the form of electrical signals via software control block of the RCE /1.5.1/ to the appropriate electronic device /1.3/. Components of the electrical control system /1.3/ are implementing the appropriate clients request in the space of the experiment itself /1.1/. Feedback of the control is realized by sensing probes and measuring instruments /1.2/, which are sending the obtained data to the control electronics/1.3/, or via server application /1.5/ using the relevant blocks /1.5.2/ and /1.5.4/ directly to the clients application /2/. Received data are processed by client's application /2.3/ and they are displayed on the computer screen/2.2/. Feedback function is also realized by scan and video stream transmission system. The picture is scanned by using the camera /1.4/ and it is processed by server application /1.5/ in the block /1.5.3/. The processed video stream is

transmitted over a computer network to a client application /2/, which is processing and displaying the received video data in the module /2.1/.

The set of all software and hardware components providing the remote experiment control by users is called structural framework or constructive system. During the development there were more constructive systems designed and successfully implemented. One of the most well known systems is LABView constructive system.[9]

## PURPOSE-DESIGNED CONTROL CONSTRUCTIVE SYSTEMS OF THE RCE

Based on economic and technical problems related to the RCE design several designers came to draft of their own control electronics and their own software control through the serial structural systems. Such a design framework is usually very closely and purposefully designed for specific task what causes an inefficient handling with time and effort of the designer. The designed closely specialized system which is used for one specific purpose only is waste of the time, knowledge and technical abilities of the designer in comparison with incurred effort. Low economic attractiveness of design of constructive systems for the RCE is logically reflected in the low number of such experiments. [10],[11]

Construction and operation of the RCE is difficult to funding, the organization and the technical knowledge of designers. From our experience we know that the operation of the RCE in the market system is not sufficient to cover even the overhead costs associated with their operation. To keep the operational capability they need to be subsidized. Discontinuance of the operation of several RCE is a result of ran out of the financial resources necessary for their operation and maintenance. [12],[13]

## INDUSTRIAL AUTOMATION SYSTEMS

Word „automation“ is becoming one of the most frequent words of the present. It is obvious because along with the development of information technology enters into all areas of human activity. Automation has become one of the important criteria in assessing the



capabilities and the overall level of the individual, society and humanity as a whole.

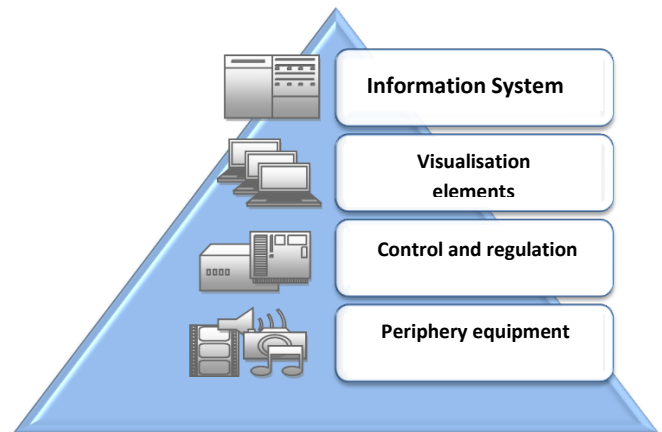
The term automation means the use of control systems (e.g. regulators, sensors, computers, ...) for control of the industrial devices and processes.

In terms of industrialization it is a step following the mechanization. While mechanization provides people with mechanical means and tools to facilitate their work, the automation means reduction of human need in the performance of certain activity. Under certain conditions (complex automation – beginning of artificial intelligence) there could theoretically come up to the total disappearance of man from the production process. However, in practice this possibility seems to be impossible yet. [14]

From the point of view of the designers it is possible to understand the remote control experiment as a remote control automation system. New possibilities for solutions have been opened for the implementers by changing the view of the RCE construction. The existing broad range of elements of industrial automation and their mutual smooth compatibility have created an unbounded space of technical combinations and possibilities of the problems. The structural design of remote control automation system with the use of industrial automation has become a challenge and motivation for verification of the technical skills of the executive team of the RCE of the Department of Technology and Information Technology at Faculty of Education, Constantine the Philosopher University in Nitra. To handle this challenge it required at first an extensive study of the problems of design and creation of the remote control automation systems. [15]

## INTEGRATED SYSTEM OF INDUSTRIAL AUTOMATION

Hierarchical arrangement of the elements of industrial automation in an integrated control system is shown in the form of a pyramid with more levels (pic. 2). [16]



Picture: 2 Levels of automation system [17]

From a functional principle, all automation systems show the presence of devices on the 1st and 2nd level (pic.2). Using sensors and measuring devices, the system detects the state of the controlled process. Through activators it interferes with running of the process what means its affection and control.

A crucial element in the regulation system is a regulating or control system (member). On the basis of the inputs it evaluates the current state of the system and decides on the activity of activators.

Levels 3 and 4 in the pyramid model present optional features of the regulatory system. These are mostly occurred in more complicated control systems. In accordance with the model scheme (pic. 2), below we will pay attention to technical and application analysis of elements which are going to be used in a technical design solution of the control of a model remote control experiment. [17]

## PLC – PROGRAMMABLE LOGIC CONTROLLER

The very process control, in the scheme (pic. 2) it is marked as a regulatory or control system, is mostly provided by PLC automats. Even from the shortcut PLC - Programmable logic controller it is obvious that the PLC automat is a control computer in its principle. Hardware and software means of the PLC automats are created at the same principle as the classic PC-type computers are. However, due to the special requirements of industrial automation they differ significantly from conventional computers in many structural modifications. The demanding requirements for parameters of working

environment such as dustiness or moisture are an example of it. Another important requirement is for compatibility which requires to be able to communicate with various group of peripheral sensors, measurement system or activators. These, as well as the other special requirements for PLCs affect their technical solutions so they are completely different from classic computers at first sight (pic. 3). [14]



Picture 1: Sample of the PLC system [16]

PLCs are used for solution of automation tasks with different technical difficulty. The impact of this fact together with a strong commercialization of their production is a development of a wide range of the PLC's types and formation of a big group of the producers.

Programming of the PLCs is realized in a development environment which is specific for every type of the PLC. The development environment is a software executable on most classic computers of PC series. The finished control code is at first tested on simulated PLC system which is normally part of the development environment. The finished program is transformed from a PC to the PLC memory system using standard communication lines such as RS232, RS485, TCP / IP, WIFI, USB, or is transmitted through normal memory cards. Control program can be run in the PLC in different ways depending on the setting of the PLC system parameters :

- a) automatically when you turn on the PLC,
- b) by setting the appropriate digital input (RUN) to the logical drive,
- c) by switching the manual switch to position (RUN).

The PLC has got a different internal system architecture in comparison with a classical computer. Its programming is therefore different from program

creation for classical computers. At the programming of the PLC there are five programming languages preferred : [13]

- a) Assembler – machine code of the system processor in the PLC system,
- b) Programming language C and its variations – extension to the machine code,
- c) STL (Statement List) – list of orders, very similar to the Assembler,
- d) LAD (Ladder Diagram) – contact scheme, very similar to electrical schemes,
- e) FBD (Function Block Diagram) – scheme of function blocks.

It depends on the specific manufacturer of the PLC system what language will be supported by its development environment. The languages STL/LAD/FBD are considered to be an industry standard which are currently supported by almost all the PLC systems. The Assembler and programming language C are understood as expanding opportunities for the programmers. [18]

### REMOTE CONTROL OF THE PLC SYSTEMS

Systems of remote control of the PLC control systems had been developed much earlier than we started to use the computer network Internet massively. It is understandable because also in the past the PLC system mounted in the electrical distributor of the automation system had to communicate with computers in the „control center “which were often apart for several hundred meters. It was directed at the development of industrial communication systems whose role did not lie in the ensuring of communication of the PLC system with computers of the control center only but also with other elements of industrial automation. Sensors, measuring devices, probes, frequency converters, pneumatic valve matrixes, switches, valves, stepping motors are nowadays equipped with industrial communication systems. The best known systems are ProfiBUS, ProfiNET, CanOpen a FieldBus. All these systems have been designed for their use in severe operating environment of industrial automation. Massive arrival of the Internet meant also new challenges and opportunities in application of remote control of the PLC systems. The distance

between computers of the workers and the PLC systems themselves are nowadays measured in thousands of kilometers. There are several elegant ways how to implement remote control of the PLC systems via the Internet.

### **COMMUNICATION MODULE SUPPORTING TCP/IP PROTOCOL**

TCP/IP protocol is communication standard in the Internet. The PLC system with such a communication module has got a physical IP address which is able to identify the system on the Internet and the related client applications can establish direct communication with it. It is necessary to say that the communication module for easier PLC systems is often more expensive component than the PLC system itself. At the same time the programmer has to bear a lot of problems in his client application which are related to communication between the PLC and the client PC.[19]

### **COMMUNICATION MODULE TCP/IP WITH INTEGRATED WEB SERVER**

The PLC system with integrated web server is an elegant solution for remote control systems in real time. Such a PLC system has a control web page saved directly to its internal web server. Response speed of the control applets running on the internal web server of the PLC system itself is not limited anymore. The use of this type of the PLC system in this case would be an ideal technical solution. Unfortunately, these systems are designed for commercial applications and they are equipped with other technical elements which would not be used in our solution (extended number of inputs, outputs, modules of industrial communication, DNS server, SMTP server, WIFI router, ADSL modem, network switch, backup power system,...) The price of such a PLC system is thousands of euros what is an impossible barrier at designing of the RCE. [19]

### **COMMUNICATION VIA A COMPUTER CONNECTED TO THE INTERNET**

Paradoxically, the cheapest and most appropriate solution is to bring a classic computer which will be acting as a communication port between the Internet and the

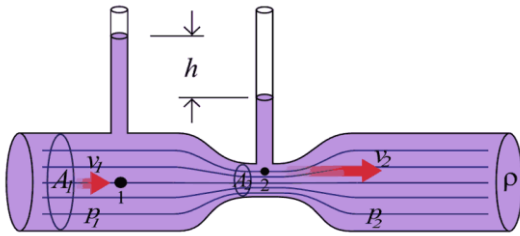
PLC system itself. Such computer is becoming a server and is acting as a communication interface between a remote client application and the control algorithm in the PLC system. Software ensuring these tasks is running on the mentioned computer and it is called OPC server (OLE for Process Control). „Classic“ technology OLE (Object Linking and Embedding – object connection and insertion) is a server service (Server OLE), which enables the applications to use the services of another applications. For example you will insert a drawing created by AutoCAD in text editor Word. Despite the absence of any possibility to edit the drawing in Word, it is possible to use AutoCAD functions and to create directly in Word (by double-clicking on the drawing) a workspace for editing drawings, along with all the functionality of AutoCAD. For software developers such a system means that they do not need to have any knowledge of processing of the video stream when they want to play video in their application. The application using the OLE server can manage to share functions of any video players. But let's get back to our OPC server. The short cut OPC in the figurative sense means OLE for process control. When programming the client application the programmer does not have to even assume what way the communication with the PLC system or server application established is. In this way the programmer does not have to think about any complications during solving many difficult problems. Communication between client applications and PLC systems via OPC servers is currently the most widespread and financially affordable solution in application practice. The producers of the PLC systems offer the designers also their own OPC servers designed for communication with their type of PLC automat. Price of the OPC server depends on the model of PLC system for which it is designed or on its technical parameters (response speed, number of simultaneously communicating clients, range of processed data, etc.). Strong competition among manufacturers of components for industrial automation has resulted in the release of licenses for OPC servers with lower technical parameters and for simpler and cheaper versions of PLC systems in recent years. [20],[21]

## RCE – MEASUREMENT OF THE SPEED OF GASEOUS ENVIRONMENT

Remote control experiment for measure of the speed of gaseous environment was model experiment, which is applicated and verified of the PLC control system. Theoretic basis of this experiment is Bernoulli formula for fluid:

$$\frac{1}{2} \rho v_1^2 + \rho g h_1 + p_1 = \frac{1}{2} \rho v_2^2 + \rho g h_2 + p_2 \quad (1)$$

$\rho$  is density of flowing environment,  $h_1$  a  $h_2$  are surfaces levels of fluid in U – tube,  $g$  – gravity acceleration,  $h$  – is difference of surfaces levels ( $h_1 - h_2$ ),  $v_1$  a  $v_2$  are velocities of fluid in points 1 a 2.

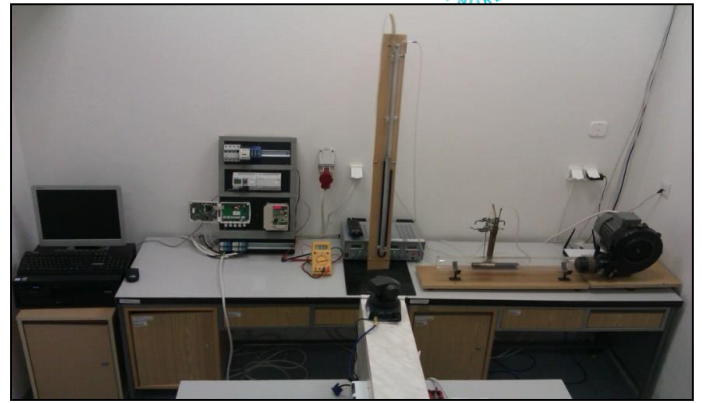


Picture 4: Venturi tube. [22]

According to this formula the assuming of kinetic and potential energy of volume element and pressure is the same in flow environment everywhere.

### MEASUREMENT OF AIR FLOWING VELOCITY IN TUBE

Measurement of air flowing velocity is realized in plexi tube with internal diameter  $D$  in this experiment. Van is connected to one of the ends of the tube. Measurement elements are installed inside of the tube. View at this remote control experiment is on figure 5.



Picture 5: View of realized RCE

Velocity of air flowing in the tube is defined by difference of surface levels in U manometer, which is connected to Venturi (Prandtle or Pitot) probe. According to

$$v_1 = d_2^2 \cdot \sqrt{\frac{2 \cdot (p_1 - p_2)}{\rho \cdot (d_1^4 - d_2^4)}} \quad (2)$$

Pressures  $p_1, p_2$  are measured by air gauge in practice. Thiers values are inserted in to formula (2). If air gauge is not available then pressure value will be calculated as difference of height level  $h_1, h_2$ , which is shown in figure (pic. 4). To calculate pressures  $p_1, p_2$  we can use:

$$p_1 = \rho_{tek} \cdot g \cdot h_1 \quad (3)$$

$$p_2 = \rho_{tek} \cdot g \cdot h_2 \quad (4)$$

$\rho_{tek}$  is density of liquid in tube,  $g$  – gravity acceleration and  $h_1, h_2$  height levels in tubes.

Industrial measurement instrument KIMO CP 300 was used for validation of measurement in the tube and calculated result in this experiment. Principe of this industrial measurement is same as measurement in the tube.

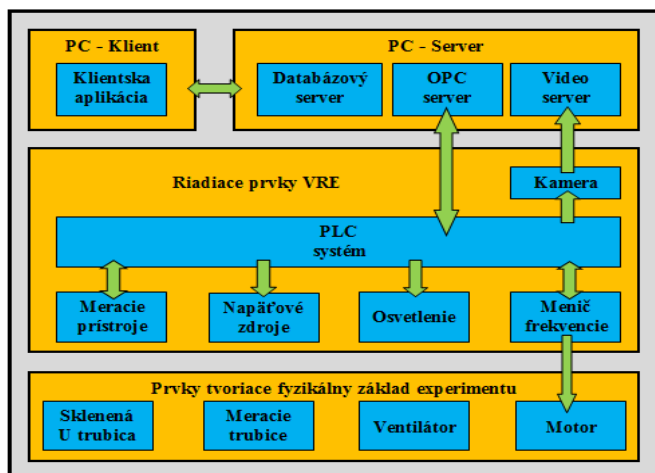
Didactic and educational aims are very important for designers of remote experiments. The aims for this remote experiment were as follows:

- to deepen the knowledge of students on relations between the basic physical parameters,
- to understand the essence of experimental measurements in solution of the physical and technical applications

- to understand procedures of physical variables measured in the experiment and to use correctly in calculations
- to understand procedure of validation and interpretation of measured functionalities
- to deepen an interest of students in creative access to solution of physical and technical tasks
- to motivate students to positive relationship to physical and technical subjects

Design and construction of this remote experiment have defined more technical problems:

- to control and to change of the rpm of the van
- to scan difference of level height in U manometer and at the same time to watch another parts of the remote experiment block scheme of the realized experiment is in figure



Pictrue 6: Blocks scheme of RCE

## SELECTION OF CONTROL PLC SYSTEM

After considering more possibilities we chose PLC EATON EASY 512 DC RC for control of remote experiment. Regulation of the rpm of van was realized by 3 phase inverter OMRON SYSDRIVE 3G3MV. For communication between client PC and PLC system there was used our own OPC server, which was programed for this solution.

Connection between OPC server and PLC system was realized by serial port RS 232.

Second key aim was to find a solution for video transmit. The first trial video stream was realized by VLC video server. Delay time of this solution was not acceptable, because value of this was 12 seconds. Such delay time was not useable for remote experiments. This problem was solved by our own video server, which was designed and programed for this solution too. Delay time of our own video server was 0.5 -0.8 sec. which was acceptable. Such a good result was achieved by our video server, which saved captured picture directly in data block of RAM memory without saving in hard disc. Data block from RAM memory was sent to users by the Internet. This system of capturing, saving and sending pictures is faster than usually used by common video-servers.

Client application was created in programming development environment MS Visual C#2008 Express Edition.

## CONCLUSION

These initial results have been achieved by solving the RCE design – measuring of air flow speed and by the implementation of the design:

- There has been designed a new software system for rpm control of three phase asynchronous motor by frequency converter, also useable for easy PLC sytems which did not have such possibilities initially.
- There have been achieved better technical communication parameters by programming our own OPC server for implementation of the RCE in comparison with original communication OPC server from producer.
- Creation of video server based on its own software algorithm, without lengthy compression methods, allowed to speed up the transfer of the video stream to match the needs of the RCE.



- The new design concept of the RCE using the elements of industrial automation has been designed and tested in practice.
- By preparing a specific RCE for measuring of fluid speed another RCE has been added to portfolio of didactic tools for teaching purposes which is useful in teaching of science and technology.

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## INTRODUCTION

The question of virtual and remote labs development and integration in common e-learning infrastructure is very popular last years.

Many engineering and science studies, including on material sciences, are based on theoretical knowledge. Engineering students nevertheless also need a lot of practical work/laboratories to acquire the knowledge and skills in procedures they will have to use in their professional career. Since time and other resources are limited to make available real life infrastructure in a classroom teaching environment, the introduction of a remote and virtual lab environment is considered as an efficient tradeoff between the necessity for lab work, and the above mentioned boundary conditions [1].

The blended learning approach shows the most efficient results among different approaches with the usage of e-learning systems. Blended learning is the combination of different methods of learning and teaching.

For the realization of a blended learning environment a multi-disciplinary team needs to be put together: the design and construction of the labs needs a lab specialist, the programming and net-integration needs software engineers and programmers, the use of the tool needs pedagogues. Only a sound cooperation will yield useful results.

## REQUIREMENTS FOR VIRTUAL AND REMOTE EXPERIMENTS

Virtual labs are a supporting tool for quick checking of experimental results, for simulated experiments. It is very useful for mass experimenting on a phenomenon at a very low cost. As it is only simulated, it does not offer the same sense of reality as a remote lab, but it gives the student the opportunity to repeat the experiment endlessly. Simulation means software made experiments. Although simulations can be used to overcome the disadvantages of traditional laboratories, any simulation is simply a model of a physical process, which is just an approximation that cannot reproduce every aspect of the real phenomenon. Some of the advantages of virtual laboratories are the availability of the experiments 24/24h, 7/7 days a week, the low cost of the experiment (only cost is the computer cost, and development cost of the software experiment) and possibility to simulate hazardous experiments. Since it is only virtual (software), no safety precautions have to be taken by the user, nor the provider of the experiment.

Remote labs aims to give students the opportunity to test on (less complicated) infrastructure, still experimenting on real experiments. Students can vary parameters, make choices, observe, measure and analyze as in the real lab. It is in fact a real lab, controlled from a different (distant) place.

## EXAMPLE OF AN E-LEARNING ENVIRONMENT FOR STUDYING FOR ENGINEERING STUDENTS

In the faculty of engineering technology of KU Leuven –campus De Nayer the Computer Aided Learning Module (CALM) was developed for supporting students

in their study on material sciences. The CALM is a blended learning platform, combining classroom teaching, an e\_learning platform, physical, remote and virtual labs. For the 2-point bending test (to determine Young's modulus) a remote laboratory to measure material stiffness and its relation to shape stiffness was constructed, in combination with a virtual lab.

Different techniques are combined: hypertext linked contents, virtual lab (ActionScript) and a remote lab (For the realization was chosen the Spring MVC Framework. The basic logic was realized with java, for visualization were used HTML, CSS, Javascript, JQuery, JSP.) [1].

## CONCLUSION

The requirements for the construction of a virtual lab and remote lab can be clearly divided in 2 categories: the technical requirements and the pedagogical requirements.

The most important question is how to use the lab in the pedagogy of a subject. The use of the lab has an impact on its technical requirements.

For pedagogical purposes the visualization and interactivity of the remote and virtual laboratory are among the most important features. This means the lab should be easy to operate, contain self supporting help, should be visually attractive and should be as fool-proof as is possible.

Developed environmental for the material science courses is an example of multi-disciplinary and multinational team work.

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