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Outreach Activities for Pre-University School Students Coordinated by the Centre for Science Education and Training*

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This paper discusses the various means we use in order to assist informal technical education in Romanian pre-university schools, from elementary to high school, in the frames of National and International projects of which we are a part. The activities are run by the Centre for Science Education and Training, which coordinates the 'Hands-on Science—Romania' Educational Network, at National level. Efforts are directed towards promoting different teaching methods (e.g. problem-based learning, science clubs, science fairs, debates) and tools (e.g. computer-based data acquisition, LabVIEW programming, virtual experiments) to develop additional skills and to enhance student interest in studying technical subjects and engaging in engineering careers. Another objective is to involve as much as possible the entire community (students, parents, teachers, local authorities, organizations responsible for teacher professional development) in common activities focused on science teaching.

Keywords: Teaching methods; LabVIEW; pre-university

INTRODUCTION

TWO PHENOMENA already affect the technically skilled workforce market both in Europe and the United States: globalization and the decrease of interest by the young in science and technology education. Official EU documents recognize that an adequate supply of scientists is crucial for a knowledge-based economy; for this reason, the Council has set as an objective 'to bring about an increase of at least 15 per cent in the number of graduates' in science related fields by 2010 [1].

In Europe, scientific literacy is viewed as a dimension of 'democratic citizenship' [2]. Voices across the Atlantic bring a similar message [3]: 'Most people in this country lack the basic understanding of science that they need to make informed decisions about the many scientific issues affecting their lives'.

An EC document issued in 2002 clearly indicates some paths to follow in the field of school education along with some precise targets: 'Europe must do more to encourage children and young people to take a greater interest in science and mathematics'. It is essential 'to motivate more young people to choose studies and careers in the scientific and technical fields in a short and medium term perspective' [4]. The Working Group on *Increasing Participation in Math, Science and Technology* made several recommendations in 2003 concerning the path to be followed for teaching science and technology in schools: 'a) the teaching of mathematics, science and technology should be an entitlement for all children from the early stages of education and should be mandatory at all levels; b) more effective and attractive teaching methods should be introduced in mathematics, scientific and technical disciplines at both primary and secondary level, in particular by linking learning to real-life experiences, working life and society and by combining classroom-based teaching with extra-curricular activities' [5].

Meanwhile, the European Union Research Advisory Board—EURAB recommended the sustained support for science education in schools:

a) 'the introduction of innovative, hands-on science education into all Europe's primary schools;
b) the introduction of Creative Science Teaching modules into the formal training period of all primary school teachers;
c) concerted efforts to mainstream science, engineering and technology curriculum and teaching innovation into secondary school systems;
d) all science, engineering and technology organizations—industrial, academic, professional, governmental—reassess and strengthen their commitment—at a local, national and European level—in supporting the development of school science, engineering and technology education' [6].

In the European Union, science and engineering education is a matter of policy, having as main pillars [7]:

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a) The *Science in Society* programme which should 'bring a strong scientific culture in Europe where research is understood as an instrument for economic growth, welfare and well-being';
b) The scientific literacy has to be built on the cultivation 'from an early age of an interest in science and the ability for critical thinking and reflection developed gradually in school and university';
c) 'Promising national experiments by teachers and others who want to implement new methods for promoting an understanding of science and research among children and young people should be specially supported at EU level';
d) 'Relevant institutional arrangements between representatives of civil society, researchers and research organizations should be established with the aim of opening up research activities progressively—beyond communication and information—towards greater involvement with society and the establishment of mutual trust'.

Rocard's 2007 Report underlined the following [8]:

a) 'there is an obvious need to prepare young people for a future that will require good scientific knowledge and an understanding of technology;
b) however, the key point is equipping every citizen with the skills needed to live and work in the knowledge society by giving them the opportunity to develop critical thinking and scientific reasoning that will enable them to make well informed choices;
c) improvements in science education should be brought about through new forms of pedagogy: the introduction of inquiry-based approaches in schools, actions for teachers training on Inquiry Based Science Education—IBSE, and the development of teacher networks should be actively promoted and supported.'

Comparable findings emerge from a recent report issued by the Nuffield Foundation [9]: 'EU countries should ensure that teachers of science of the highest quality are provided for students in primary and lower secondary school; the emphasis in science education before 14 should be on engaging students with science and scientific phenomena. Evidence suggests that this is best achieved through opportunities for extended investigative work and "hands-on" experimentation and not through a stress on the acquisition of canonical concepts'.

International studies revealed the importance of teachers' professional development support by dedicated scientists through in-service training, new partnerships, networking opportunities, involvement in the assessment of the educational process, common research programmes, mentoring and assistance in writing grant proposals [10].

Nowadays, the most demanding segment of the educational chain to be drastically improved seems to be science teachers, as indicated by expert studies. The National Board for Professional Teaching Standards listed five principles for accomplished teaching [11]:

- 'teachers have to be committed to students and their learning;
- teachers have know the subjects they teach and how to teach those subjects to students;
- teachers are responsible for managing and monitoring student learning;
- teachers think systematically about their practice and learn from experience;
- teachers are members of learning communities'.

ROMANIAN EXPERIENCE IN ENGINEERING EDUCATION OUTREACH

As Romania became a member of the European Union, new strategies on science education in schools were devised both to tune Romanian policies to the European and to bring our original contribution to the achievements of the Community. The Laser Metrology and Standardization Laboratory at the National Institute for Laser, Plasma and Radiation Physics has created, after its participation to the European Comenius *Hands-on Science* Network [12], the Centre for Science Education and Training—CSET [13]. The Centre start-up was financed by the Romanian Agency for Scientific Research through the contract *Science Education and Training for a knowledge-based society—SET 2010*.

The mission of the Centre for Science Education and Training is to support the education and training in science for everyone, and the main objectives of our educational outreach activities are:

a) to support for the development of the Romanian education system (elementary/ middle/ high school/ vocational) through training in natural sciences using real and virtual experiments;
b) the coordination at national level of the *Hands-on Science—Romania* educational network, as part of the International Association *Hands-on Science*;
c) to promote the best European practice and to establish a partnership between the Romanian teams and advanced networks in Europe in the field of education, for the technical and scientific knowledge and lifelong learning;
d) to develop a regional network (in the Balkan area and in the East and Central Europe) aimed at increasing the quality of science and engineering teaching at the pre-university level;
e) to reinforce the dissemination at the national and international level of the main results regarding science and technology education obtained in Romania.

In order to fulfil some of the requirements associated with modern science teaching approaches and methods (see Introduction) we set up the Centre's strategy in relation to technical education in schools. This strategy is aiming:

a) to support the inclusion in the school education plan of subjects related to real-life problems and focused on emerging job market needs;
b) to assist high schools in developing real and virtual experiments;
c) to transform the school (teachers and students) from classical end-users of teaching and training aids into active designers and developers of such materials;
d) to use IT&C technologies as efficient tools for the democratization of science teaching, by preparing teaching materials in electronic and multimedia format;
e) to facilitate the access to experiment-based teaching to less favoured groups;
f) to assist—with funds/ consultancy/ advertising—those able to craft another face to the traditional teaching schemes and to create new, unexpected teaching aids;
g) to disseminate the project's results though lectures, conferences, communication sessions to a large pool of recipients and beneficiaries (students, parents, teachers, central and local authorities, NGOs, companies involved in the teaching process);
h) to build strategic partnerships with organizations and companies which can assist us to run the project, either through direct financial support or by associating the project name with their brand.

The main achievement we can claim for the activity of our Centre is derived from the great variety of implementation means (courses for teachers and students, science fairs, exhibitions, contests) and the large age span of the students involved, from elementary to high school.

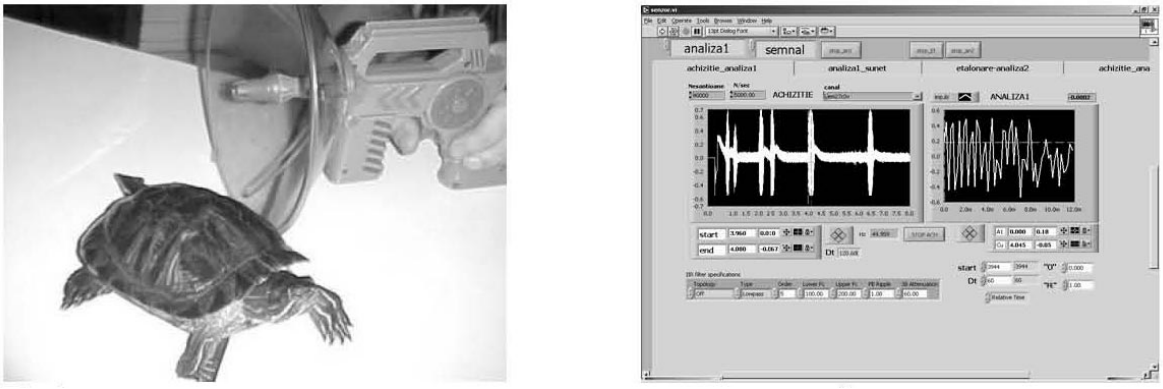
Support for the development of the Romanian educational system

In the field of engineering education of high school students we identified several areas of interest, from the points of view of field novelty and employment opportunities:

a) computer-assisted laboratory experiments;
b) education in photonics;
c) education in robotics and electronics;
d) education in chemistry;
e) education in sustainable development;
f) education in history of science.

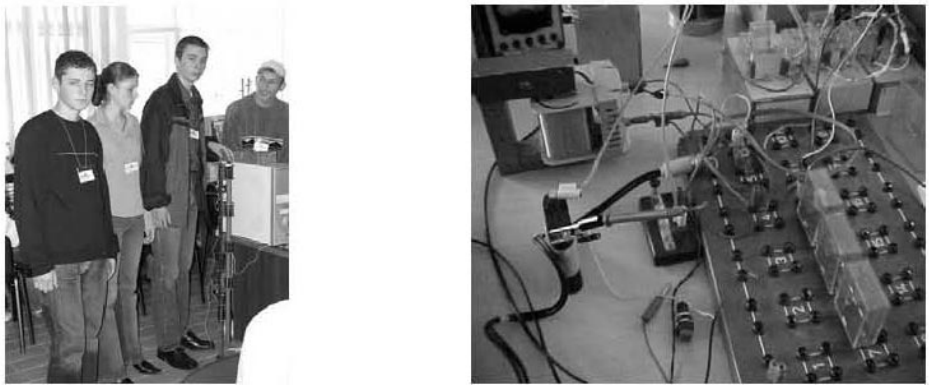
Until the launch of our partnership with Romanian schools, IT was used in teaching only for virtual lessons, either based on Internet resources or developed in Romania by several software companies. We brought through our projects two major new elements: training on the use of virtual instrumentation, and the development of real experiments employing various sensors controlled by a PC. The use of virtual instrumentation was based on LabVIEW programming. The Romanian Ministry of Education initiated an educational program in cooperation with National Instruments by distributing free LabVIEW licences to several high schools in Romania. Some of the beneficiaries started to use the graphical programming environment to develop simple virtual experiments; in the meantime, a team from The University of Bucharest delivered some LabVIEW courses to schoolteachers preparing for a Master degree. From these premises, we pushed further the use of virtual instrumentation in schoolteaching by offering data acquisition boards and different sensors to seven partner schools in order to run real experiments. More than 60 students (grades K-8 to K-12) were the direct beneficiaries of these donations. The breakthrough was a major one as:

- schoolteachers and students were able to develop their own real-life related experiments (Figures 1 and 2);



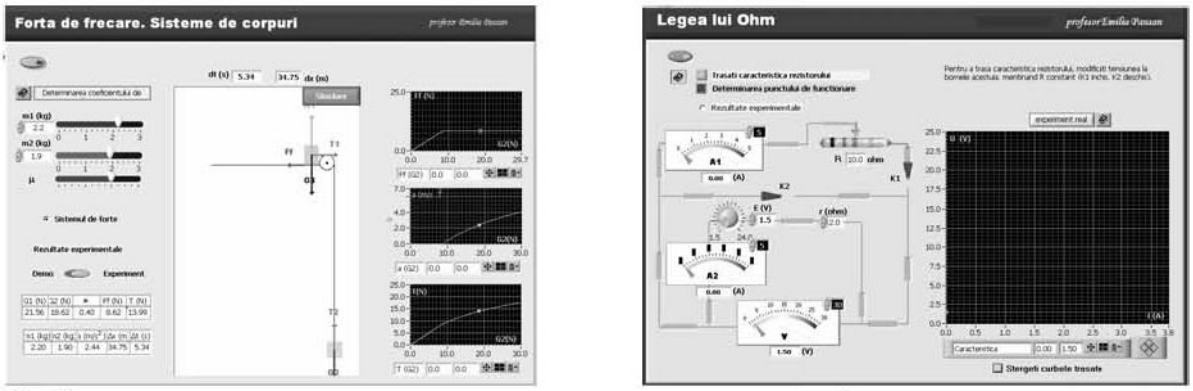
(a) (b)

Fig. 1. Investigation in the school laboratory of sounds emitted by animals: a—the automatic data acquisition; b—the analysis of the captured signal (Courtesy Mrs Mihaela Garabet and Mr Ion Neacsu, teachers at the G. Moisil Theoretical High School in Bucharest).



(a) (b)

Fig. 2. Use of virtual instrumentation in the study of: a—different falling bodies, through the measurements of the currents induced in coils placed along the object's path; b—study of Ohm's laws (Courtesy Mrs Emilia Pausan, teacher at the T. Vladimirescu High School in Bucharest, Mrs Mihaela Garabet and Mr Ion Neacsu, teachers at the G. Moisil Theoretical High School in Bucharest).



(a) (b)

Fig. 3. Virtual Physics experiments run under LabVIEW (Courtesy Mrs Emilia Pausan, teacher at the T. Vladimirescu High School in Bucharest).

- the interest on LabVIEW programming proliferated;
- more virtual experiments built around LabVIEW were implemented (Figure 3).

We are very satisfied with these achievements as far as LabVIEW programming is more usual at university level [14–18], and, at least in Europe, we can claim to be the first to have an accredited course on LabVIEW programming for school teachers, and one LabVIEW course for students.

Today, LabVIEW-supported set-ups cover experiments related to static electricity, force studies, mechanical motion, chemistry, as well as environmental studies. In the latter, we started a project having as subject the climate change, in cooperation with The Holy Cross College in UK. The British and the Romanian teams were awarded in 2008 the Rolls-Royce Science Team Award for 'an outstanding contribution to science teaching'. Romanian teachers achieved remarkable skills in designing virtual experiments with LabVIEW and in teaching thermodynamics, electricity, mechanical motion, optics or nuclear physics. The enthusiasm of some high school teachers resulted in the creation of a web site, operated in the frame of the national educational network *Hands-on Science—Romania*, dedicated to the use and teaching of LabVIEW [19], where a student forum is hosted.

The popularity of LabVIEW programming in Romanian schools led to the creation of a dedicated section to the national annual LabVIEW Users' Conference organized by Politehnica University in Bucharest. Our efforts to promote LabVIEW programming in schools were rewarded by the two awards our partner teachers received in 2006 (First Prize) and 2007 (Jury Award) at the National Conference on Virtual Education run under the patronage of the University of Bucharest, Faculty of Mathematics. Some of the teachers' papers were also presented at international conferences on education.

In order to encourage the introduction of computer-based laboratory experiments in Romanian schools we supported two high school teachers who were preparing an e-textbook describing original laboratory experiments in physics, chemistry, biology, human physiology and environmental sciences. Our partners in this

project were Microsoft Romania, National Instruments, USA and Vernier International, USA. The book is available in Romanian to be downloaded for free from our Centre web site. Meanwhile, demo sessions using various types of sensors in school laboratories are carried out in Bucharest and in six other major cities. Five training courses with about 20 participants per course were organized on the use of these experiments.

Romanian school curricula include several courses on classical optics and little information on modern optics. For this reason, the task of introducing additional training in photonics is not trivial, as even school teachers are not prepared in this subject in an appropriate manner. The results we had in supporting the use of LabVIEW in schools encouraged us to proceed with the introduction of photonics-related subjects as extracurricular activities. Our strategy in this field is centred on several points:

- the development of simple training aids to support the curricula;
- improving the general scientific literacy of the public in relation to modern optics and photonics issues;
- training of school teachers to use and to teach photonics-related topics.

In a broader understanding of modern optics and photonics we shall try to address in our activities subjects related to:

- light and vision;
- light and colour;
- lasers;
- optical fibre systems and their applications;
- image processing;
- optical spectroscopy and its applications in physics, chemistry and life sciences.

Generally, there are very few teaching activities that cover these topics in Europe, and for this reason, we have turned to the United States to acquire the needed experience. For about one and a half years we have cooperated with the New England Board of Higher Education [20], who are running online courses on photonics (the PHOTON2 project) for school and college teachers with financial support from the National Science Foundation. Within this collaboration, one Romanian school teacher attended online classes for 12 weeks in 2007 and graduated as the first non-American to do so. Today she is pursuing the second phase of the training on photonics, a course based on a problem-solving approach. During her participation in the second course she started a virtual forum on problem-based learning with photonics related subjects [21], in both Romanian and English. In this forum, Romanian students ask questions and American experts answer. In a way, this is another premiere at a transcontinental level. The success of this online course has made possible the enrolment of two Romanian school teachers for the 2008 photonics course. We expect to develop here a team of expert teachers.

Another programme related to optics education refers to the cooperation we have with the National Optics Astronomy Observatory in the United States [22], which has been running in the past years the *Hands-on Optics* programme at national level. Within the frame of this collaboration NOAO have donated training kits to partner schools in Romania. Additionally, a training workshop for Romanian school teachers delivered by a NOAO scientist took place in April 2008 in Bucharest. The course was attended by 55 elementary and middle school teachers from Bucharest and five other towns; 70 per cent of the attendees were women. The interest in these methods of teaching optics was so high that we are planning another round this Fall. On the occasion of the course we also organized an exhibition with optics-related experiments for K-3 to K-7 students, to be attended by about 40 participants. We have to remark that more than half of them were girls. Members of the National Parents Association also attended the events, as they expressed their interest in the after-school activities we organize.

Our efforts to promote the teaching of optics and photonics in Romania are reinforced by other means:

- with the help of our sponsors we have offered some optical fibre-based mini-spectrometers to partner schools in order to be able to run up-to-date experiments in physics, chemistry, life sciences;
- we have provided demo kits for optical fibre communication experiments;
- we are working with school teachers on the presentation of laser- and photonics-related experiments in order to be included as examples in accredited school textbooks.

The use of spectrometers and optical fibre links in schools is not a common thing even in developed countries in Europe. One of the spectrometers was used by partner school teachers to prepare experiments which are now included into the 2007 12th grade textbook.

Our achievements in promoting photonics teaching in Romania were recognized by two major professional societies: the Optical Society of America (OSA) and SPIE, which have provided training aids, as well as educational posters translated into Romanian. Recently, CSET has received donations from both OSA and SPIE to further promote optics education in Romania, and was invited by OSA to be the Romanian partner in activities celebrating the International Year of Astronomy in 2009. We are distributing these materials to our partners for free. Very recently, SPIE has awarded a grant to our Centre for the procurement of additional instruments intended for photonics teaching.

To support chemistry teaching and to increase the students' interest in chemistry related careers we are promoting at national level the *Xperimania*

(a) (b)

Fig. 4. Demonstrating LEGO robots: a—during the 'Researcher's Night'; b—at the National Research Fair 2007 (Photos from the authors' archive).

Project project run by the Association of Petrochemicals Producers in Europe [23].

The tremendous impact robot toys have on children of all ages is well known [24]. For this reason we have decided to introduce robot programming as an alternative to traditional curricular education. We have started with demo sessions in schools based on the LEGO Mindstorms robots kits (Figure 4). This approach is matched with LabVIEW programming teaching. Teaching robot-based experiments is also an absolute first for Romania, and we expect to be a rapidly growing educational segment. One such demo session was held during the annual Romanian Research Exhibition in 2007.

We are offering support for Electrical/Electronics teaching mostly through after-school programmes, such as those we are organizing in conjunction with the Children's Club in Pitesti, to which we donated a complete kit to be used in teaching electricity. With this kit they are providing demo sessions to more than 80 students (K-7 to K-9) in local schools.

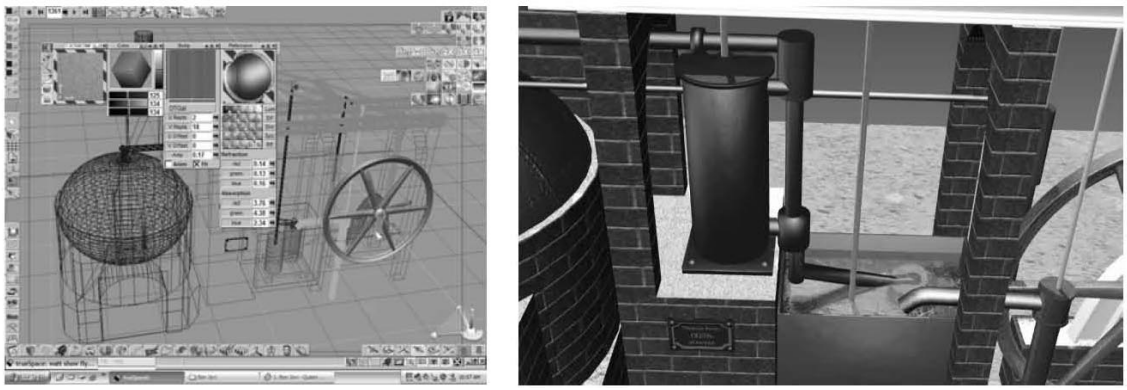
Being aware of the role played by environmental education in forming a responsible citizen, we established special programmes devoted to this subject. We are supporting teachers training on climate change, pollution issues and environmental impact of human activities. One of the most representative achievements on this subject is a project run by a partner school which is monitoring underground water pollution with various sensors in the town of Galati, situated on River Danube. The direct outcome of this activity was the invitation received by the team of teachers and students to deliver a presentation during the annual conference of Dunarea de Jos University in Galati. Other activities refer to alternative energy sources (i.e. photovoltaic cells). Quite recently, we supported one of our partner school (Liceul Grigore Moisil in Bucharest) to participate in an international contest for innovative teaching methods in Zagreb (Croatia) with a set of experiments aiming to demonstrate the influence of global warming.

Part of our philosophy in teaching technology in schools is focused on the influence of science history on the evolution of various technical concepts. This activity has two major components: Internet investigations on the evolution of a specific device/ instrument/ technical concept; the way computer graphics can be used to teach science history. The first approach is quite a recent one for us and is part of the cooperation with an extended European Comenius project—*EPMagazine* [25]. At the beginning, our contribution will be the translation into Romanian and distribution through our web page of their articles; the next step will engage Romanian school students to produce their own contributions. An example on the evolution of the mobile phone was already posted by a 14 year old student [26]. The second activity is based on the use of 3D graphics and animations to reproduce some technical well-known achievements. Figure 5 depicts the wire-frame and the final design of Watt's double-acting steam engine.

Apart from the above-mentioned fields we support extracurricular educational activities on astronomy, biology, consumer protection. As astronomy is a fascinating subject to youngsters we started a series of easy lectures addressed to primary school students and carried out by a Romanian teacher who attended the NASA/ Honeywell Educators@Advanced Space Academy course in 2007. After the presentations, students were asked to express in an artistic way their understanding of the problems introduced to them. Following these interactions the teacher started a blog on this subject [26].

Coordination of the Hands-on Science—Romania *Educational Network*

Another direction of our engineering educational outreach consists in the coordination of the national educational network *Hands-on*



(a) (b)

Fig. 5. 3D animated model of Watt's stream engine: a—the wire-frame for the graphics, designed according to the original drawings; b—a screenshot of the final product (Courtesy Radu Sporea).

Science—Romania. The main focus in this case is the organization of:

- training courses for school teachers;
- science club activities;
- contests for students;
- communication sessions on science and technology issues;
- science fairs;
- distribution of teaching aids;
- demo sessions.

As we are aware that in the present situation of technical education in Romania at pre-university level the greatest challenge is the professional development of school teachers, we supported the delivery of several courses on LabVIEW programming and virtual instrumentation in relation to science experiments in school labs. The courses are accredited and are delivered by our partner teachers in cooperation with the Romanian Teachers Professional Organization. Generally, the courses cover 6–8 days of training and include hands-on experiments. Based on these courses, teachers obtain credits for their professional records. In the last two years, more than 80 school teachers attended the course on LabVIEW programming. Additionally, two classes of about 25 high school students (16–17 years old) graduated the course for students.

Another approach, addressing a larger pool of beneficiaries is formed by week-end demo/training sessions. In this case, an attendee diploma is issued and the training is delivered on site. We have a mobile laboratory and a team of two experienced trainers go over the weekend to different towns where 60–80 school teachers attend a short two days course. Last year we visited several locations across Romania (Piatra Neamt, Galati, Cluj, Slatina, Pitesti, Suceava), including less privileged ones (high unemployment rate—Valea Jiului; rroma populated villages— Ramnicu Valcea county).

Meanwhile, the Director of the Centre for Science Education and Training visits during weekends various communities across the country and delivers technical presentations on subjects covered by our activity. The general audience is formed by teachers, school inspectors and school principals.

An important component of our teachers' education on technical subjects is represented by the training of primary school teachers by hand-on/brains-on experiments, in order to be able to expose students at an early age to inquiry-based learning. These activities are carried out as part of our contribution to the European Union's 'Pollen' project [27]. A good example in this direction is the course for primary school teachers and kindergarten educators we organized last October with over 60 participants under the direction of two French instructors with the Pollen team support. Based on this experience, four primary schools in Bucharest and one in the city of Galati started Inquiry-Based Science Education (IBSE) programmes, engaging over 120 pupils (K-2 to K-6). One of the focuses of our approach on science teaching at very early ages is the interaction with parents who attend most of our demo sessions.

School students and teachers can bring to the public their technical projects through communication sessions, science club activities and science fairs. Generally, science club activities gather the participation of pupils and teachers from the same community (about 40 to 60 students coordinated by 8–10 teachers), are generally run Saturday mornings and are followed by an artistic programme. Communication sessions have a wider participation (i.e. neighbouring towns), and are formed by several concurrently running discussion panels. An interesting example of such an activity is the Symposium (more than 350 participants from 12 to 17 years old) we organized in March 2007 having "Light" as their subject. At this event, different technical aspects related to the generation, measurement and applications of this form of energy were discussed. Three times per year we plan science fair activities in various towns, with over 150 participants each time. Within this

context, exhibitions with experiments and the technical achievements of students are organized, superposed with science-related experiments and demo set-ups in physics, chemistry, biology, robotics and environmental sciences. For the last two years, the jury of our major science fairs (ScienceFair@Moisil.ro) was formed by foreign invited professors from Austria, Croatia, Germany, Hungary, India, Italy, Malta, Portugal, Serbia, Sweden, Turkey, UK, Ukraine and USA.

The impact of personal example is very important, so we are doing our best to bring scientists and engineers to school communities to deliver talks on hot subjects. We invited Dr Teodor Negoita, the renowned Romanian polar explorer to speak about his lab at the South Pole, and Dr George Nemes from Stanford University to deliver a presentation on meta-materials.

In 2005, celebrating Einstein and the World Year of Physics, a national contest of drawings took place with Science and Technology subjects (i.e. Renewable Energy, Environmental Protection, Space Sciences) with more than 280 entries (Figure 6).

CSET has several agreements to distribute educational materials for free (over 250 CDs, 150 DVDs, 100 posters, 180 magazines in printed and electronic format) to Romanian schools. For example, we are offering course support on astronomy and environmental issues produced by The Institute of Physics in UK, or the *Science in School* European magazine.

Another important activity refers to the mentoring and free consulting for our partner schools in preparing proposals for national and European grants.

Promotion of best practice and partnership

One of our goals is to form, at national level, a community of teachers, school principals and school inspectors interested in promoting study of technical disciplines in schools. Apart from this national dimension we are also targeting the integration of our efforts into the European mainstream, by bi-lateral cooperation, regional networks and common projects. CSET has organized, in the last two years, two international workshops focusing on Scientific Literacy and Lifelong Learning and Science Education in Schools with invited speakers from Austria, Belgium, Bulgaria, Croatia, Denmark, France, Germany, Greece, Hungary, India, Italy, Malta, Portugal, Sweden, Turkey, USA, UK, Ukraine. In the Balkans area we have close connections with similar groups from Serbia, Croatia, Turkey and Bulgaria.

CSET acts now as an observer member of the EU's 'Pollen' project [27]. It is a founding member of NYEX [28] and of the International Association *Hands-on Science*, and it is a member of EUSCEA [29].

Support for dissemination at national/ international level

We strongly support our partners presenting their results on engineering education at national and international events. For the last three years, Romanian teachers' participation in the international conference *Hands-on Science* reached 28–32 per cent of the conference papers.

In November 2005, CSET organized a booth at the *Communicating European Research* Conference in Brussels (Figure 7 a). In 2007, it participated with teams of students and teachers to Researcher's Night and the National Research Fair (Figure 7 b), events coordinated by the Romanian Authority for Scientific Research. These last events were firsts in the field because we have brought the students' technical achievements to the general public, in an environment dedicated traditionally to research entities.

One other goal of our Centre is to promote to the general public science and technology achievements and the challenges our society is now facing. Our approach is a little bit unusual, because, instead of delivering public conferences and presentations, we engage school students in promoting our message through exhibitions, open days and demo sessions. In these circumstances, CSET coordinated in 2007 the activity of a High School in Bucharest in relation to *Earth Day*, a science communication session on environmental problems. The *Europe Day* was also celebrated in

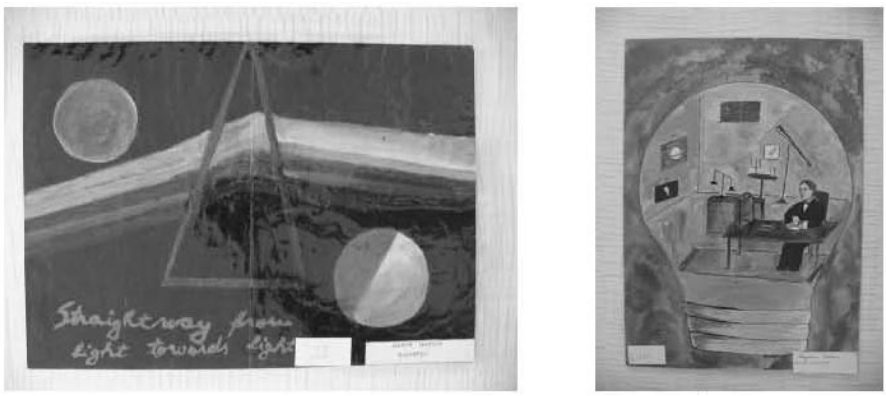


Fig. 6. Drawings celebrating the World Year of Physics (Photos from the authors' archive).

(a) (b)

Fig. 7. Participation of Romanian team in science communication events: a—the *Hands-on Science* project booth at the *Communicating the European Research* International Conference in Brussels, November 2005; b—Research Fair in Bucharest, 2007 (photos from authors' archive).

2007 in different towns by school students participating in science fairs run in parks.

Our continuous efforts to promote science education in schools were recognized in 2008 by the Romanian Academy of Sciences which invited us to deliver a talk on this subject at the national workshop on the future of Romanian science held this March in Bucharest.

CONCLUSIONS

More than five years ago, we dedicated ourselves to the promotion of science and technology education at pre-university level. Our experience in this field can be summarized:

1) There is a lack of experimental means available in Romanian school to teach science and engineering. This situation directs studies towards an excessive theoretical approach so that students miss the opportunity to encounter a real engineering education. We are actively trying to bring real life problems as an educational base at pre-university level (i.e. pollution monitoring, expertise for consumer protection, introduction to robotics and alternative energy sources).
2) The Romanian educational system is based exclusively on the passive, teacher-centred method. Efforts have to be made to implement an active, student-centred educational model, based on direct involvement of the students in the learning process through an inquiry-based, participative education. Within this new frame (education based on experiment and centred on the inquiry approach) we continue to achieve remarkable results as it involves students' interest and their participation.
3) Teachers are not prepared to develop practical lessons with a hands-on touch. We have to deliver more courses for teachers in technical fields, courses complemented by an assortment of demo sessions.
4) Considering the poor financial support offered to Romanian schools we think that a national programme based on the open educational resources concept has to be launched, by developing teaching materials to be downloaded for free from our web site.
5) The build-up of a national educational network focused on science and engineering teaching is mandatory in order to support science and technology education at national level and to push further the interest of young people in these subjects. The network has to be both a real one (gathering schools, parents' associations, local authorities, business community from the same neighbourhood, which can be easily done for some events), and a virtual one structured on specific themes and interests (i.e. study of biology, environment, robotics, etc.).

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REFERENCES

1. Commission of the EC, Commission Staff Working Paper. *Progress towards the Lisbon Objectives in Education and Training*, Brussels (2005).
2. Implementation of Education and Training 2010, Work Programme, Working Group B *Key competences, Progress Report* (2004).
3. Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, Editors, *America's Lab Report: Investigations in High School Science*, National Academy Press, Washington, D.C. (2006).
4. Commission of the EC, *European benchmarks in education and training: follow-up to the Lisbon European Council* (2002).
5. European Commission, *Implementation of the Education and Training 2010 Work Programme, Progress Report* (2004).
6. EU Research Advisory Board—EURAB, *Working Group on Increasing the Attractiveness of Science, Engineering & Technology Careers, Background Document*, EURAB 02.054 final, (2002).
7. EU Research Advisory Board—EURAB, *"Science and Society": An agenda for a responsive and responsible European science in FP7*, EURAB 05.035 (2005).
8. Rocard's Expert Group 2007 Report, *Science Education Now: A Renewed Pedagogy for the Future of Europe,* Brussels (2007).
9. J. Osborne and Justin Dillon, *Science Education in Europe Critical Reflections*, A Report to the Nuffield Foundation (2008).
10. Committee on Biology Teacher Inservice Programs, Board on Biology, Commission on Life Sciences, National Research Council, *The Role of Scientists in the Professional Development of Science Teachers*, National Academy Press, Washington, D.C. (1996).
11. Committee on Science and Mathematics Teacher Preparation, Center for Education National Research Council, *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium,* National Academy Press, Washington, D.C. (2001).
12. http://hsci.info
13. http://education.inflpr.ro
14. N. Ertugrul, Towards Virtual Laboratories: a Survey of LabVIEW-based Teaching/Learning Tools and Future Trends, *Int. J. Eng. Educ.* **16**(3), 2000, pp. 171–180.
15. T. L. Schwartz and B. M. Dunkin, Facilitating Interdisciplinary Hands-on Learning using LabVIEW, *Int. J. Eng. Educ.* **16**(3), 2000, pp. 218–227.
16. A. B. Buckman, A Course in Computer-based Instrumentation: learning LabVIEW^{TM} with Case Studies, *Int. J. Eng. Educ.* **16**(3), 2000, pp. 228–233.
17. W. D. Smith, G. B. Williams, R. Berguer and J. T. Anderson, LabVIEW^{TM} Facilitates Interdisciplinary Team Projects in Graduate Biomedical Engineering Courses, *Int. J. Eng. Educ.* **16**(3), 2000, pp. 234–243.
18. J. B. Olansen, F. Ghorbel and J. W. Clark, Jr., Using Virtual Instrumentation to Develop a Modern Biomedical Engineering Laboratory, *Int. J. Eng. Educ.* **16**(3), 2000, pp. 244–254.
19. http://www.pss.ro/science_fun_club_romania
20. http://www.nebhe.org
21. http://physicsexperiments.forumup.ro/forum-1-physicsexperiments.html
22. http://www.noao.edu/education
23. http://www.xperimania.net//ww/en/pub/xperimania/homepage.htm
24. B. Erwin, Martha Cyr and Chris Rogers, LEGO Engineer and RoboLab: Teaching Engineering with LabVIEW from Kindergarten to Graduate School, *Int. J. Eng. Educ.* **16**(3), 2000, pp. 181–192.
25. http://www.epmagazine.org/
26. http://daretodreamatstars.blogspot.com
27. http://www.pollen-europa.net/?page=CLDGDJVwskY%3D
28. www.nyex.info
29. http://www.euscea.org

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