NEW TRENDS ON LIGHT AND OPTICS' TEACHING. BUILDING BRIDGES TO THE INFORMATION SOCIETY. THE OPTICA'XXI PROJECT.

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ABSTRACT

In our emerging Society of Information, Light and Optics have a crucial importance not only in Science and Technology but also in the widest range of aspects of our every day life. In this communication we will present a project presented to the EC program Socrates action Comenius 3.The project aims the establishment of a network, the OPTICA XXI network, involving eighteen educational institutions from seven European countries and a transnational consortium (CoLoS - Conceptual Learning Of Science). Our activities are focused on the development and promotion at European scale of new positive good practices on teaching optics and optics related technologies at basic and secondary schools by leading the students to an active volunteer and committed participation in the teaching/learning process through practice and experimentation, making intensive use of the new instruments and resources of the Information Society. Text and workbooks with electronic interactive versions will be produced in all languages of the countries involved. Educational hands on kits of experiments with different levels of difficulty, from basic optics to photonics and telecommunications, will be produced and commercialised. Interactive web sites and virtual simulation tools and labs will be established. Two international conferences will be held as well as a number of courses for schoolteachers and contests and activities for school students.

Keywords:
Basic Schools, High schools, hands on experiments, Information Society

1. INTRODUCTION

In our days Optics and Photonics have a major increasing importance not only in Science and Technology but also in the widest range of aspects of our every day life. In the emerging Society of Information Light and Optics have a crucial importance, soon unsurpassable with the new developments in many photonics' fields including, fiber optics sensor and communications, image acquisition and processing, lasers, medical applications of light and lasers (photodynamic therapy, non-invasive medical diagnostics, surgery, tattoo removal and skin conditioning, tooth cleaning, ophthalmology,…), real time holography and data storage, optical computing, industrial non-destructive testing and metrology for quality control, environment monitoring (air and water quality, pollution detection, ozone layer depletion, ...) and life sciences, material processing (annealing, cutting, welding, drilling, ...), artwork cleaning and restoration,…

It is of utmost importance that soon in their education the students get introduced or acquainted on those subjects of general optics -geometrical, physical and quantum- but also on more advanced subjects of striking importance: wave guidance, fiber optics and telecommunications, image digitalisation and processing, light-matter interaction, optical processing and computing,…

Seventh International Conference on Education and Training in Optics and Photonics,
Tuan-Kay Lim, Arthur H. Guenther, Editors, Proceedings of SPIE Vol. 4588 (2002)

The new stringent requirements of the modern society demand not only the gathering of specific knowledge but also and specially the ability of acting interactively to be able to find, analyse and solve new interdisciplinary problems.

The best way of achieving an adequate formation of our students on these issues is by inducing the students to an active committed participation in the teaching/learning process, through practice and experimentation. Making use of the new instruments and resources of the Information Society.

The current situation in the countries involved in what concerns the teaching of optics and photonics at school level differs. However except in the UK the level is clearly insufficient. However there is the clear perception of the increasing importance of these subjects and things are evolving positively specially in Portugal, Greece and Slovenia. In Romania the economic and social problems over the last decades had a very negative influence, however the teachers still have a reasonable level of preparation on these topics.

2. OUR MAIN STRATEGY

In order to induce new positive good practices on teaching optics and optics related technologies at basic and secondary schools we decided to establish an enlarged network of educational institutions in a number of different European countries. Within the network several topics will be discussed and focused activities undertaken.

Specifically our pedagogic approach to the problem relies essentially on three vectors: hands on experiments (learning and self learning by experiment practices – the scientific method); conceptual learning (learning and understanding fundamental concepts in optics and science in general by the integration of qualitative and intuitive understanding with quantitative methods, in order to promote inventive behaviour and problem solving skills); and, intensive use of ICT (computer simulations and demonstrations, interactive multimedia material, automated virtual laboratories, web-based networks for exchange of ideas and experience and pedagogic tools and materials, in a national and international basis).

3. NETWORK OBJECTIVES

In order to establish a sound and feasible work plan we defined a chain of goals. In general they are:

- to develop and stimulate new ways or better ways of teaching optics and photonics at school level.
- to develop in students an intuitive understanding and feel for science
- by creating internet pages (including the creation of virtual laboratories and tools), organizing conferences (including Internet-based teleconferences) courses and meetings on the subject,
- promoting visits of school teachers and project coordinators between institutions in different countries,
- establishing educational experimental kits,
- promoting school activities aiming to captivate the students… to see, to discuss, to play with, to enjoy, to have fun, to feel the trill of discovery, to wonder them selves with the world of optics, physics and sciences in general.
- to contribute to the development and dissemination of new multimedia tools of free open equitable access to persons with disabilities and minorities.
- to enhance the teaching of science using innovative and highly interactive software
- to explore new ways of using computers in scientific learning

- to create a network of teachers interested on this subject to serve as possible future coordinators of educational projects.

A number of specific goals was established some a local level:

- Development of educational hands on kits: Light and Colour (from pre-primary students); Elementary Optics (students up to 12 years old); Basic Optics (12 to 16 years old); Introduction to Optics (from 14 years old); The basics of Fiber Optics (12 to 16y) ; Introduction to Fibre Optics and Telecommunications (from 14 years old) ; Introduction to Lasers and Metrology (from 14 years old); Liquid Crystals (from 14 years old).
- Production of textbooks and written material on the different topics of our theme with different level of difficulty. Those materials should also be prepared in electronic multimedia and interactive support.
- Preparation and delivery of several courses for schoolteachers.
- Development of syllabus of Optics courses for different school levels.
- Production of computer simulation of different topics: from simple ones like the reflection and refraction process, or colour combination, to more advanced one like liquid crystal theory and holography.
- Development of three simple virtual laboratories placed in different countries.
- Establishment and diffusion of web sites on these issues in all national languages of all participating countries.
- Realization of two international conferences on teaching and learning optics in non-university schools.
- Realization of one workshop on the same topic devoted to an audience from Eastern European countries.
- Annually the organization of Science Fair Contests in each country opened to all.
- Establishment of a forum for the exchange of ideas and experiences in a permanent informal way through a web based e-network linking all the project members.
- Direct exchange of experiences by promoting mutual visits of teachers (hopefully also students) between institutions in different countries.
- An Internet based e-network will be established to link permanently (and continuing well after the formal end of the network's activities) all the partner Schools and Institutions.
- Provide a complete picture over the scientific research in Optics throughout the history as a meaningful pedagogical tool.

Directly involved in this projects' activities will be over one hundred school (pre-primary to secondary) teachers and over 5000 students.

Indirectly on the conferences, the courses, the video-conferences and science contests, an universe of many hundreds teachers not exclusively from the partner countries directly involved but also from eastern countries by the workshop that will be organized in Romania, and from the countries with members on the CoLoS association. A huge universe of teachers, educators, education agents and, of course, students will profit from those activities as well as the educational experiments kits and the written and multimedia material to be developed.

In order to attain the best possible diffusion of our activities within our target groups (pre-primary, primary and secondary school teachers the corresponding students and young's in general, but also all those persons that late

on their lives decide to study science, opinion formers and all the education agents) we count with the support of national government' institutions, firms of educational material, international associations and even TV stations.

4. NETWORKS' COMPOSITION

Our network involves several Universities, Research Institutions, National Government Boards, Private companies, Colleges and Schools and School' Associations from Portugal, Greece, Spain, UK, Italy, Slovenia, Romania, Germany, and the CoLoS (COnceptual Learning Of Science) pedagogic association. The main goal of our project "New Trends on Light and Optics' Teaching. Building Bridges to the Information Society. OPTICA'XXI" is to contribute to the improvement of Optics and Photonics teaching at non-university level.

The network counts with the formal involvement of 20 Institutions of different types covering all education levels from pre-primary to basic, secondary, technical and university levels, working in different environments, cultural, and socio-economical backgrounds -large towns, medium sized towns, and small villages, some in rural or industrial areas- covering a large varied geographical area from the Iberian Peninsula, Southern Northern and Central Europe to the Eastern Europe. They will focus their activities in teaching the basic or more advanced concepts (of lasers and photonics for instance) of Optics and Photonics, in a less theoretical way, by using of the experimental analysis, extensively employing advanced ICT tools, or simple hand made materials, in integrated interdisciplinary approaches or analysing the issues in a more sectioned way. Different approaches, different feelings, the same conscience, the same objective: to evolve to a new positive approach of participated active teaching of Optics and Science in general at school level.

All of the partners have previous experience on the development of innovative educational practices in a non university level and many are or were involved in national projects of these kinds and on international collaborations within the EC or with EC and Latin American' schools. The project coordinator has a large experience on the coordination of educational projects in experimental, hands on, approaches of teaching optics and physics in basic and secondary schools, as well as on the development of educational kits and web sites on optics and physics subjects.

The National Institute for Laser, Plasma and Radiation Physics in Bucharest has an extensive experience in EU international cooperation programs (PHARE, PRAQIII, Leonardo da Vinci, PECO, EURATOM) some in cooperation with the Theoretical High School "Horia Hulubei". The University of Ancona coordinated several EU's projects also on industrial non-destructive testing. The Loughborough College is involved in several projects related to medical and industrial applications of lasers, and delivers courses at different levels on those topics. The University of Vigo have a strong experience on cooperation projects (including EC' ALFA) with different institutions in Latin America. All the basic and high schools are presently involved or were recently in pedagogical research cooperation projects many in the field of hand on experiments learning. The Group of schools TEIP is currently establishing a Centre of Science devoted to teaching the basics of Science to pre-school and school students. The Koper Gimnasium has a permanent cooperation of the Trieste synchrotron, and the Aspra Sipition High School is involved in project on the topic the History of Science. The Universities of Maribor and Ljubljana and JNIS companies have a large experience in the creation of web sites, web based network and on formation on related topics.The CoLoS consortium have a large number of works undergoing now including in the development of applets for teaching optics and physics. The Slovenia Board of Education is the responsible at national level of establishing the educational policies in Slovenia in these fields. Most of these Network members had (or still have) previous fruitful cooperation relations in this or related topics.

5. EXPECTED OUTPUTS

A number of educational, hands on, experimentation kits will be projected covering the major different fields of optics and photonics. Associated to these training modules several guides will be written. Interactive web sites

will be implemented and multimedia products produced. The setting up of virtual labs with a few basic experiments on optics will be studied.

A number of reports including the comparative analysis of our activities' results in different schools and countries will be delivered.

We intend to proceed with the formation of a number of pattern makers on each of the schools or countries. A number of teachers will gather enough know how to serve in the future as dynamizers of the dissemination of those good practices.

The largest possible publicity of our work and work outcomes will be made, locally, countrywide and internationally in order to disseminate as widely as possible the good practices to be introduced.

Two International Conferences will be held on the first year of the project and on the final months of it.

On each of the primary or secondary schools involved, the respective Project' members will organize with their students the "Optics and Photonics Days" open and offered to the schools the students families and the community. During these hands-on activities days, the schools will welcome a group of students from another school of another country, that will bring and present a Science project they own developed within the "Optics' projects Contest" organized on all the schools participating in the project.

Courses to be delivered:

- General Optics:
  - Basic
  - Introductory
  - Advanced:
    - Lasers and applications. Lasers and Optics in Medicine and Biology
    - Photonics. Metrology and sensors
    - Fiber optics
- Laser safety
- Introduction to fiber optics and telecommunications
- Hands on experimental practices in Teaching Optics:
  - to basic schools (8 to 12 years)
  - to secondary schools (13 to 18 years old students)

Educational hands on kits to be developed:

- Light and Colour (from pre-primary students);
- Elementary Optics (students up to 12 years old);
- Basic Optics (12 to 16 years old);
- Introduction to Optics (from 14 years old);
- The basics of Fiber Optics (12 to 16y) ;
- Introduction to Fibre Optics and Telecommunications (from 14 years old);

Introduction to Lasers and Metrology (from 14 years old);

Liquid Crystals (from 14 years old).

Textbooks and guides on the different topics of our theme with different levels of difficulty will be published. Versions will also be prepared in electronic multimedia and interactive format. Hopefully all the material will be published in all the national languages of the different partner countries.

General syllabus of Optics courses for different school levels will be established.

We will also create computer simulations of different topics: from simple ones like the reflection and refraction process, or colour combination, to more advanced one like liquid crystal theory and holography.

Three simple virtual laboratories will be set-up: in Portugal "Light and Colour"; Spain " Mirrors and lenses"; and Slovenia "Liquid Crystals).

A web site of the network connecting interactively all the participating institutions will be established. National web sites on these issues in all national languages of all participating countries will be created.

We expect to organize two international conferences on teaching and learning optics in non-university schools in fall 2002 in Slovenia and in September 2004 in Portugal.

An workshop devoted to an audience from Eastern European countries and aiming the diffusion of our activities and pedagogical methods and outputs, will be organized in Romania probably in 2003.

Annually in each country we will be organize Science Fair Contests on each country opened to all and focused on Optics and Photonics.

An electronic newsletter on our activities and on the theme of "Teaching and Learning Optics and Photonics in the Information Society" will be created.

6. PLANNING OF ACTIVITIES

Our project has a minimum duration of three years. But on view of the number of tasks scheduled and the size of the network to be established, spite the fact that our theme is rather clear and specific, the Network activities is expected to be active for two more years.

It is desirable, and we will make strong efforts on that direction, that the network will gather new partners and collaborators not only in EC but also all over the world.

Our activities will be distributed and coordinated on a country basis. Many tasks will involve institutions from different countries. However it is important from the organizational point of view this kind of hierarchy ,with a general coordinator and national coordinators, to be established.

We divided our activities per year and trimester. By the end of each trimester the national coordinators should prepare a report on their partner' member activities. The network coordinator will draw a final annual report. An evaluation of the evolution of the activities is done locally and by the general coordinator every trimester.

The activities begun with a first meeting of all country and institution' coordinators in order to distribute specific tasks for the first 6 months of the project that will include the preparation of the first international conference with the generic title of "Teaching Optics in the Third Millennium". The conference will be open (and seek) to contribution from the widest range of researchers and educators interested on the subject, aiming to establish a clearer idea of the current situation and state of the art in the EC and the world. A first general meeting of all project's participants will be held in order to set-up and approve the general and local tasks schedule of activities for the rest of the project. By that time and for roughly 2 years a number of actualisation courses will be held at the higher educational institutions for the school teachers participating on the project but open to the local

community. Just from the first months of the project web sites will be created in order to present the evolution of our activities. As well the first versions of the web pages on optics subjects will be made available and upgraded throughout all the project' length.

The establishment of the educational kits and activities will accompany those activities.

During the second and third year of the project an exchange of educators from different schools in different countries for short/medium periods of time will take place. Every year, on each of the involved schools a series of activities on the "Optics and Phonics Days" will be organized with the school students open to the school, the students' families and the community. A hands-on activities "Science Projects' Contest" will be organized involving the students of all schools participating in the Project. To the group of students author of the "best" local project will be awarded a visit to one of the other schools were the project will be presented by the students themselves within the "Optics and Photonics Days". The Contest on last' Project year will be open to all non-university students of the countries involved in the Project and within the EC. A number of science projects will be selected and their authors invited to attend the final Projects' International Conference. Annual general meetings of all member of the project team will be made, detailed reports being generated. The end of activities will follow immediately the second international conference to be organized. The results of our activities will be presented and publicly assessed. The general evolution of the state of the art of teaching optics and photonics will be evaluated. Final conclusions will be drawn.

In Romania the local partners with cooperation of members of other countries when possible will prepare and execute a number of informal courses and demonstration sessions in rural and particularly poor and neglected areas, including gypsies communities in the interior of Romania.

A workshop will be prepared in Romania aiming the presentation and discussion of the themes of our network with teachers and institution from Eastern countries. The workshop will take place tentatively in July 2003.

An ISDN Multipoint videoconferencing system will be established between all countries and institutions involving also a Slovenian TV station (TevePika).

The transnational character of our network is stretched by the participation of different institutions from different countries in the development of all tasks. In particular we would like to point the common curricular activities of the Spanish College "Martin Codax" and its neighborough School EB 2,3/S de Celorico de Basto. A strong interaction will also occur between the Slovenian School "Koper" and the neighbouring Synchrotron of Trieste in Italy (that although not a forma partner of our network will closely cooperate with the Gymnasium Koper and the University of Ljubljana in the studies of synchrotron radiation).

Countries general assignments:

Greece (GR) – History of Light and Optics (Texts, web site and interactive material), video conferencing.

Spain (SP) – Introductory Optics, lasers, metrology, fiber optics, web pages, virtual experiments, video conferencing.

England (UK) – Lasers, interaction of light with materials, bioptics, video conferencing.

Romania (RO) – Lasers, laser safety, metrology, web pages and interactive material, computer simulations, video conferencing.

Portugal (PT) - Introductory optics, fiber optics, interaction of light with materials, metrology, virtual experiments, video conferencing.

Slovenia (SL) – Liquid crystal, synchrotron radiation, multimedia, interactive material, web sites, virtual experiments, video conferencing.

Italy (IT) - Interaction of light with materials, metrology, computer simulations.

An Internet based e-network will be established to link permanently (and continuing well after the formal end of the network's activities) all the partner Schools and Institutions.

On completion of the three years of this project's activities a number of materials in the form of educational hands on kits, text books and multimedia materials, computer simulation and web sites, courses materials and syllabus, that will allow the continuation of the types of activities we propose and hopefully in an every improved way. As well the participating school you have available a number of equipments and material of support, as well as a sound experience, that will allow them to continue their activities hopefully involving other topics and contributing to the national and international dissemination of these good practices.

7. CONCLUSION

Clearly understanding the major outstanding importance of Light and Optics in our World of Future we decided to establish the OPTICA'XXI network, we briefly presented above, joining the effort many teachers and scientists all over the world are undertaken on studying and developing actualised and more effective ways of teaching optics and photonics in the widest and more generalized way.

We strongly hope that our work and ideas in close interaction and cooperation to all colleagues and Institutions involved in this effort, may in fact contribute for the construction of a better world; were a fast and sound development of science and technology is a priority opening our eyes and minds to new Worlds; making each men a better Human.

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