

# Hands-on Science

Costa MFM

## Introduction

In the Society of our days there is a major increasing need of an in depth quality education in Science and Technology.

Science teaching at school should be generalised aiming not only the sound establishment of a “Science” culture in our societies but also to guarantee a steady basis for the improvement of Science and its technological applications.

Urgent actions should be taken in this direction. By initiative of the author the “Hands-on Science” (H-Sci) network was created. The European Commission under the program Socrates, Comenius 3 action (project n°. 110157-CP-1-2003-1-PT-COMENIUS-C3) supports the network.

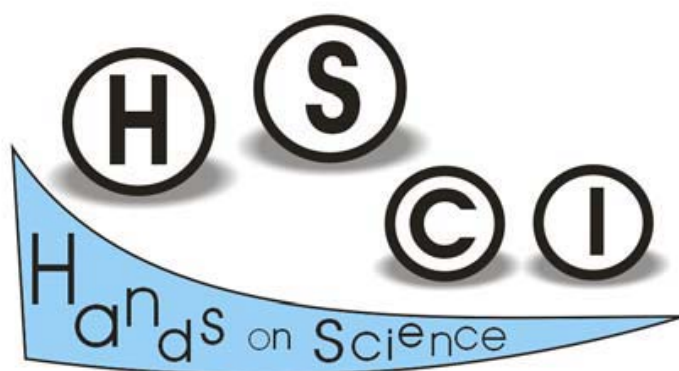


Figure 1. The symbol of the network

The activities of our network focus on the development and or diffusion at European scale of positive hands-on experimental practices on teaching science at basic secondary and vocational training schools. By leading the students to an active volunteer and committed participation in the teaching/learning process through hands-on practice and experimentation, making intensive use of the new instruments and resources of the Information Society.

Hands-on practices are being very successfully employed in Science Museums' Clubs and Associations throughout Europe, as major motivational but also learning

tools. The benefits of the use of these methods in the classroom are being illustrated for already some years in the USA and in some EU schools. It is now the right time to generalise the use of these practices in an effort to raise the levels of scientific literacy and expertise among our youngsters.

Science and Technology have always been issues of fundamental importance to the development of the countries and societies. Today this is, definitively, also true. No sound development can be foreseen without a strong S&T infrastructure. The fundamental basis of it is, indubitably, a well-prepared motivated reliable and flexible workforce. Scientific and Technological literacy is also of great importance for citizenship and democratic participation in a world where Science and Technology issues and demands have a dominant role.

The increase of literacy in Science and related technical expertise will induce the creation or development of high-tech industries or services' firms that are of fundamental importance for Europe's growth and development. Thus being a pro-active factor of direct impact on the inclusion of new, and less developed, country members in the EU. Not only a long-term effect is foreseeable but also an immediate impact by raising the expectations of the economic agents and of the society in general.

A clear picture on the status of Science and Technology Education in European Schools should be made available. As well a number of policy recommendations and tested pedagogic material will be made available. A network of experts on this topic will be established. A raised awareness of the importance of this theme will be established in steady basis.

## **Pedagogical and Didactical Approaches**

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 [1]. Making use of the new instruments and resources of the Information Society.

Our pedagogic approach is focused on inducing an effective learning of science subjects and basic competencies as responsibility, method, self control and reward, critical reasoning and observation, commitment in collective group actions, interaction and proactive inter-dependence.

Hands-on activities are proved to be the most effective way of acquiring these competencies for the vast majority of child and adolescents [2]. Whenever advisable a constructivistic [3] approach will be used. It is sometimes necessary to allow the students to have a first qualitative conceptual contact with the issues of science. Conceptual learning will be integrated and used in our hands-on practices. We will use virtual simulations of natural phenomena always simple and inducing or requiring interaction with the students in a way that the qualitative perception of the concepts of Science may lead to a quantitative interpretation. The Physlets [4] first developed at the Davidson College in the USA are accepted to be a good tool that

will be explored in this context, and exported to other fields of Science. Different approaches to this issue of the use of ICT including virtual simulations in Science teaching will be discussed and assessed. The use of ICT in teacher training will also be explored [5]. The produced guides will be formative summative and making constant appeal to critical reasoning, observation and active commitment of the pupils. They will be expert' reviewed and tested in-class, and receive students and school evaluation. The heterogeneity of pupil's interests, abilities, experiences and future wishes should be carefully assessed also by contrasting the responses between different countries, languages, minority groups, cultures and gender. This analysis, that will be published and widely publicised, will conform the development of the pedagogical materials and syllabus to be produced for different countries, populations and languages. We will try to establish bridges between the industry and employers, the schools and educators, and research institutions. Suggestions will be developed on how to establish this kind of links (local and international co-operation settings will both be considered). Syllabus and guides to be developed will also take into account this interaction.

The assessment of the network is considered fundamental. We will seek both internal self-evaluation but also from external educational government boards, Educators Associations, relevant local government entities, teachers and especially from students and their parents. Inquests and questionnaires will be prepared and delivered to the different evaluators. The experience of the ROSE' (The Relevance Of Science Education) project coordinated by the University of Oslo, will be taken into account [6].

Our pedagogical and organisational strategies follows the guideline determinations of the USA' National Science Education Standards (National Research Council, 1986) actualised and adapted to the actual, and local, social cultural and educational situation in the EU. We place a special focus on the pro-active commitment of teachers and educators in motivating, inducing and conforming the autonomous realisation of broadband hands-on scientific activities by keen and active pupils.

## **Goals and Outcomes**

Our goals and field of intervention is rather wide. Below we list the main activities goals and outcomes of our network on the first 3 years of the project and beyond.

## **Main Goals and Activities**

We expect this network to serve as starting point for the generalisation of the use of hands-on active learning of Science in EU Schools.

1. we will collect and sum up continuously knowledge, information, materials, ideas, curricula and experiences from past and ongoing Socrates (Comenius and others) projects in related fields;
2. collect and monitor results and expertise achieved in former and on going pedagogic research projects in Europe and abroad in hands-on learning at

- schools in the various fields of Science.
3. develop an instrument/strategy of data collection on students' (6 to 18 years old) opinions, experiences, interests, priorities and perceptions, in particular of the relevance of Science.
  4. discuss and develop theoretical perspectives and practical approaches sensitive to the diversity of backgrounds
  5. induce the presentation of a variety of COMENIUS 1 and 2, and MINERVA projects, and others (at national and multinational level) including in the contest of the 6th framework, involving members of the network and others. Those projects will allow the achievement of several of our most important goals.
  6. assess discuss develop and test ways or better ways of using hands-on learning at the school.
  7. describe good practices and transform these into better practices in Teaching and Learning Science.
  8. induce an interdisciplinary integrated approach to Science learning through experimentation.
  9. induce the discussion and exchange of ideas and experiences among the different participants on the network.
  10. discuss and promote the issue of Science literacy for citizenship and Life-long learning.
  11. create an open web based network, a privileged forum for sharing ideas and diffusing our works' results
  12. by creating internet pages (including the study of the development of virtual laboratories and tools) and Internet-based teleconferences and courses in the different national official languages,
  13. by creating an web-based discussion Forum to be used by and open to all the school teachers, educators, parents and responsables for the local, National and EU Science and Education policies.
  14. promoting exchange visits of schoolteachers and project co-ordinators between institutions in different countries.
  15. organising international conferences and thematic workshops on this subject.
  16. inviting the community to be involved in our discussions
  17. promoting and delivering training courses for school teachers and educators in different languages and countries
  18. establishing guides and guidelines, translated to national languages on new specific hands-on experiments.
  19. promoting hands-on experimental in-school activities
  20. promoting Hands-on-Science contests and fairs at school regional national and EU level.
  21. to induce the establishment of Discovering Science Students' Clubs within the schools.
  22. to contribute to the development and dissemination of new ICT and multimedia tools of free open equitable access to persons with disabilities and minorities.

23. to contribute to induce and facilitate the access of women to Science.
24. to proactively contribute for a faster positive inclusion of the future new EC members.
25. to develop policy recommendations for the curricula' improvement
26. to create a network of teachers interested on this subject to serve as possible future co-ordinators of educational projects and pattern makers.

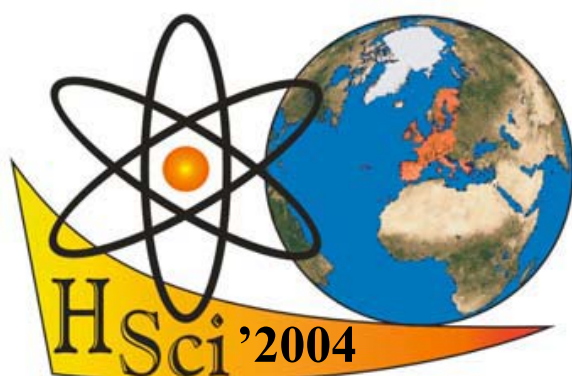


Figure 2. The network' first International conference on "Hands-on Science"



Figure 3. The "Ideas for Science Fairs" European contest is expected to involve many hundred students all over Europe.

We expect to have a positive impact in social inclusion of minorities. In particular in what concerns the gypsy community in Romania and immigrants and religious minorities in countries like Germany, Malta or Portugal. In some of our Schools there are a large increasing number of minorities that need special attention. The use of the kind of activities we propose that induces an active voluntary commitment of the students in concrete tasks can have rather positive effect contributing to a better integration of minorities in the School and in the community. Furthermore these activities lead to an organisation of the students in groups were each student will have a common appealing goal.

To the gypsy community in Romania will be given a particular attention. Lectures and demonstrations will be delivered to those communities in deprived areas in the interior of Romania.

We consider that hands-on teaching of girls in School age may contribute to define a clearer perception of Science on this group of students approaching helping bring more women to Science and Technology. The ways of achieving this goal will be discussed explored and assessed.

Close attention will be given to the possibilities and benefits of hands-on science activities in special education schools for children with disabilities. Pedagogical materials and strategies will be developed and in class tested. We expect to prepare other projects in a near future in order to deal with this specific problem.

The issue of Science literacy connected with the each day more important adults'

and life-long education will also be addressed also in the sense that a positive appealing initial or basic contact with science may certainly lead to an effective sustainability of the interest about Science and Technology during life.

We also have as a major general goal to contribute to a faster positive inclusion of the future new EU members in an enlarged Europe.

### **Main Outcomes**

1. Teaching recommendations
2. Syllabus proposals
3. Web-based discussion forums
4. Web-pages and sites
5. Virtual laboratories and experiments
6. Translated reports and written material
7. Guides and pedagogical guidelines in official national languages
8. Catalogue of projects
9. Catalogue of books and guides
10. Info folder about the network
11. Electronic newsletter
12. Teachings packages
13. In-school motivational activities
14. Three International Conferences and thematic workshops
15. Several training courses Comenius 2.1 project's proposals
16. Several Comenius 1 project's proposals
17. Internet based video-conferences and meetings in local national languages
18. Network of Discovering Science Student' Clubs.
19. Network of pattern makers in hands-on learning of Science.

### **Target Groups and Expected Impact**

To our knowledge it is the first time such a wide network is established in Europe to address the issue of hands-on learning of Science and Technology. Taking profit of the new ICT technological developments in modern society we will support complement and integrate the Hands-on quantitative study of Science with Constructivism and Conceptual and Interactive Engagement qualitative Learning. Indirectly the beneficiaries of our activities will be the Science' schools students not only in the involved countries but also in all EU current and up-coming member countries.

Specifically we will be targeting the following groups:

1. School' students (directly several thousand including those of Associated Schools)
2. Teachers and educators
3. Schools involved in the network (including a large number of associate members from hopefully all EU countries)
4. National coordinators of the network (10)

5. Education boards (4 network members)
6. Teacher training Institutions (10 network members)
7. Research institutes (12 network members)
8. Responsibles of National and Trans-National educational programs
9. The local communities and the industry

The impact of our activities depends on the target groups:

1. The network participants will get a clear idea of the state of the art on hands-on learning of the different subjects of Science.
2. The network participants will be able to serve as pattern makers in their schools, communities and countries in the subjects of hand-on experimental learning of Science.
3. The network participants will establish an enlarged number of international contacts that will enlarge their perspectives as educators but also as citizens of an enlarged European Union.
4. Raised awareness of the importance of international partnership among teachers, schools and governments.
5. Schools and educators will have a proven idea of the true advantages and possibilities of the pedagogical use of hands-on experimentation in the teaching and learning of Sciences.
6. Pupils will have raised knowledge on a number of topics and will have a new international perspective about science, teaching and education.
7. Students of the participating schools (the networks ones and other to be associated) will acquire new competencies and be aware of its importance.

### **Partnership Composition**

The “Hands-on Science” network involves several Universities, Research Institutions, National Government Boards, Private companies, Colleges and Schools and School’ Associations from Portugal, Greece, Spain, UK, Slovenia, Romania, Germany, Belgium, Malta and Cyprus, and the CoLoS (COnceptual Learning Of Science) pedagogic association.

The network counts with the formal involvement of 29 Institutions of different types covering all education levels from elementary secondary, special education, technical and university levels. Also a large number of associate member are already involved from the participating countries and from France, Denmark, Norway, Holland, Slovakia, Austria, Belarus, Bulgaria and Russia (observer). Further associate member will be accepted along the development of the network activities, in specific task forces or thematic groups.

Different institutions working in different environments with distinct cultural and socio-economical backgrounds – in large towns, medium sized towns, and small villages, some in rural or industrial areas- covering a large varied geographical area from the Iberian Peninsula, the Mediterranean, Southern Northern and Central Europe to the Eastern Europe. They will focus their activities in exploring and promoting the use of hands-on experimentation teaching by 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 positive approach of participated active hands-on experimental learning of Science at school level.

All partners have previous experience on exploring and or developing innovative educational practices and materials in a non university level and many are or were involved in national projects of these kinds and on international collaborations within the EU or with EU and North and Latin American' or North-African Institutions.

Some of the participating schools have relatively large (up to 30%) groups of pupils from minority groups (language, race, religion) and are experienced in developing pedagogical approaches to deal successfully with the problems that situation poses. A number of schools are experienced in Distance Learning and most have already proper facilities (some financed through EU projects). Several network member institutions had or currently have members of their staff participating in curriculum development efforts in science and technology organised by the respective Ministries of Education, Science and or Culture.

The CoLoS consortium brings together research teams from many US and European Universities (from the DE, UK, IT, RU, SI, FR, ES, PT). It aims to promote the development of innovative teaching methods in science and technology focusing on: learning and understanding fundamental concepts in science; the integration of qualitative and intuitive understanding with quantitative methods; and the use of simulation and network-based material.

A number of different Schools and Institutions will be involved in the Network' activities as associated members. Among those a few will a role focused on evaluation and or dissemination of the network activities and results. The associated schools and institutions will not only be informed of the network activities, have privileged access to web based network and to the produced reports and materials, as they will be asked to participate in the activities of the thematic groups as extensively as possible.

A numbers of Observer members from countries outside the EU will be accepted and welcomed.

## **Implementation Strategy and Plan of Activities**

Our network is a relatively large one either in terms of the number of partners and countries involved, or by its theme involving all fields of science all levels of School teaching with an extensive range of general and specific goals. In fact this network will be the starting point of a significative number of projects (Socrates and others) addressing specific topics or goals.

In order to maintain the network with a manageable but sufficient size in order to fulfil all requirements and develop its activities efficiently, we proceed with a selection of partners on view of their expertise and previous experience in co-operation projects particularly with other members of the network' team. A relatively large group of associated members was established enhancing the impact of our activities.

We decided that the network needed a 3 full year's period of activity to achieve the



direct goals and outcomes and specially to guarantee its sustainability in the years after the formal end of the project. An efficient decentralised and hierarchically organised system of administration of the Network on all its aspects will be established.

The network Coordinator (the author) will ensure the proper efficient development of the network. A Steering Committee formed by the all the National Coordinators and the Network Coordinator will meet (frequently by video-conference) as frequently as needed every year in order to: analyse the development of the work; assessment of results; writing down reports and further support material; proceed with data diffusion and public relations.

In regular basis each National Coordinator will contact all the responsables of the member institutions of their country recalling their work results. A short report will be issued and delivered to the Network Coordinator that will disseminate it by the entire network members for discussion and improvement. Whenever final conclusions, among the Network, are achieved they will be published in the web site in order to extend the discussion to the community. Boards or offices of the National and supra-national Educational institutions will receive that information directly.

Most of the meetings will be (whenever possible) made in the form of web based video-conferencing. Most of them will be open to all Network Members that often will be specifically invited to take part on the meeting. The in person contact between the Network members is considered very important and will be made whenever possible also during the exchange visits and workshops to be organised throughout the different Partner Countries but also on the General Network Meetings that will take place during the Annual International Conferences.

At least once a year of activities the Network Coordinator will travel to Brussels in order to meet the representatives of the Socrates Program to present and discuss results, reports and activities schedule for the following year. The eventual participation of National Coordinators could be considered.

Annual International Conferences will be held on the middle of each project's year and will be attended hopefully by the entire network members. Furthermore it will be open to all scientific and educational community (including students and their parents). The community will be invited to participate not only in conferences and thematic workshops but also in courses and motivating/promoting activities in the classroom or at School.

This network is organised in a top-down/ bottom-up structure. This means that not only the Network Coordinator and National Coordinators will induce actions produce reports guidelines and induce discussion and interaction. Also all the Network Members on his thematic groups or taskforce or individually through his group will present suggestions, initiate discussions prepare reports and organise local or multilateral activities.

The General Network Meeting presided by the Network Coordinator (once a year during the annual conferences) is on the top of the hierarchy of our structures and to which the Steering Committee will report.

The network workforce will be divided into thematic groups and fourteen main task forces:

T1. Management	T8. Web based networking
T2. Data collection and analysis	T9. Tools and practices for HSci learning of Science
T3. Meetings, workshops and conferences	T10. Virtual and multimedia hands-on material
T4. External projects promotion and integration	T11. Training of teachers
T5. Impact, evaluation and monitoring	T12. In school activities
T6. Reports and publishing	T13. Exchange visits
T7. Public relations and dissemination	T14. Cross culture, equal opportunities and inclusion

Although all fields of Science will be covered by the network activities, a few topics will be specifically addressed in: Physics, Ecology, Chemistry, Geography, Biology, Archaeology, Robotics, Maths,.... Interaction between these thematic groups will occur.

Transversal thematic workshops will be organised: “The access of Women to Science” in Germany in June 2004, “The challenges of EU’ enlargement on Science literacy and Development” in Malta, fall 2005; and “Science Literacy and Life-long Learning” in Romania in July 2006.

In January 2004 we launched the 1<sup>st</sup> European Contest on “Ideas for Science Fairs” with which we hope to induce the generalisation of the organisation of Science fairs in the Schools.

During each annual meeting a workshop will be organised where we will present our work and discussing it with industries’ representative and of the community. Their ideas and demands will be organised and will condition the further development of our work.

Several Comenius 2.1. projects will be presented by network members in order to develop a number of training courses in the different languages and participating countries. Most of them having an informal interactive structure aiming to allow the teachers/educators to feel the advantages of this pedagogical approach. Practical tools will be giving to the teachers in order to allow them to immediately begin introducing hands-on activities in their classrooms. Other topics will surely appear along the way. By the moment and already for the next call we expect to present 5 projects on “Elementary Optics”, “The use of virtual interactive simulations in science teaching”, “How to establish an In School Science Forum”, “Robots. On the way to the future”, “Feeling Life and ecology”. On these topics and in others like “All different all the same” involving “regular” and special education schools in Portugal, Spain and Greece, or “The world of photonics” different Comenius 1 project proposals will be made.

The schools involved on the project will play the most important role. However in the network close to each one of them we intend to have a higher educational institution working close together. Several motivational activities will be organised in the different countries inside the school in extra-curricular activities like informal seminars, Science fairs and contests, but also as in-classroom intervention were

the students will execute a number of hands-on experiments. A general set of experiments covering the different disciplines of Science (ecology, light sound and waves, geology the earth and the environment, biology animals and plants, genetics and reproduction, speed and mechanics, electricity and energy, sun and space, chemistry, shapes and forms, ...) and education levels (up to 10 years old, 10-13, 14-16, 16 to 18) will be studied and supplied to the schools for assessment of the materials themselves and different approaches of its practical in class use.

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.

Web based meetings and teleconferences will be used as extensively as possible. An ISDN multipoint videoconference system will be established. The use of virtual hands-on learning tools will be explored. Different approaches will be implemented and tested. Translations and adjusts will be made at Country level. The Science Fairs and Students' Science Clubs that will be organised will have virtual versions. A suitable and simply platform will be created allowing a straightforward organisation of virtual web-based Science Fairs and students' a Science discussion e-forum.

The careful assessment of the teachers and students feedback on the Project's activities and product' outcomes will be made and is considered fundamental.

We will seek an enlarged involvement of Industries and of the work-world in general in order to get their feedback on educational and special competencies needs. We also aim to gather a cluster of companies (including major industries that will be invited to attend our meetings and assess our activities and outcomes) able to ensure the development and financing of the networks' activities after the official expected end of the H-Sci network.

## **Evaluation and Dissemination**

The assessment of the network is considered fundamental. Internal self-evaluation will be made in a country and task basis. At least twice a year the Steering Committee will access the evolution of the network activities and establish corrective measures whenever needed. The evaluation will be made in two levels: in what concerns organisational matters, and on the evaluation of the quality of the pedagogical material and activities developed. Reports will be generated and publicised. By the end of each year reports will be presented to Educational government boards, Educators Associations, relevant local government entities, teachers, students and their parents. Their assessment has a major importance. Inquests and questionnaires will be prepared and delivered to the different evaluators.

In the network global web site there will be a space for evaluation and discussion of progress and results open not only to the network members but also to all interested. National web sites, dynamically linked to the global website, will include a space for pupil's opinions and intervention. A data processing strategy will be

established during the first months of activities of the network being adjusted as necessary. The strategy will be made available to all interested for use or discussion.

Acquired data will be statistically analysed and conclusions drawn. The network will also request access, and analyse and process the corresponding data, to the current exams and evaluations on the schools and students involved in activities developed by suggestion or authorship of the network.

The Project and Projects' activities and outcomes will be widely publicised.

Apart from the International Conferences and workshops the results of our activities will be presented in different conferences and congress in relevant subjects. As well several papers will be published in International Journals.

A network of pattern makers on these subjects will be established involving all countries participating in the Project.

Several EU project proposals are expected to be presented in the future based on the present project' results. It will aim to enter also the vocational training market, for life-long education in optical and optics related fields, mainly to support the working force re-conversion to jobs related to the expanding applications of Science.

We count with the support of several National Governmental boards or institutions to help us publicising and disseminating our activities and outputs. Also on the evaluation of our activities and outputs he count with the cooperation of: the Slovenian Board of Education (formal partner of the network); the Ministry of Science and Education of Romania; the "Unidade Ciência Viva" of the Ministry of Science and Universities in Portugal; The DCL company at EU level; and the CoLoS association at European level. Several members with the status of observers will have an important role as evaluators of our network development.

The Internet based e-network established linking all the participating institution will be another way of dissemination of our activities and outputs.

The opinion of all the students involved on our network activities will be expressed in volunteer anonymous inquests that will be prepared. The results of the inquests will be statistically treat and the main conclusion taking in great account.

The monitoring and evaluation on the national (Slovenian) level will be accomplished through direct involvement of the Slovenian Board of education.

The assessment of all our project output by the scientific and educational community during the scheduled annual conferences will represent a major contribution to the evolution of our work and to the establishment of our final conclusions.

The DCL firm will consider the possibility of production and commercialisation of any educational material we may develop.

## **Conclusion**

The pedagogical usefulness and effectiveness of in-class hands-on experimental activities is clearly proved in different school levels and disciplines.

We intend to further prove and make this evident contributing to invert decline of interest among young people for science studies and careers.

Our “Hands-on Science” network aims to strategically induce the creation of a realm of learning that will give the students the competitive edge in the new Knowledge-based Economy. We plan to grow steps in the sense that schools may in fact become incubators for nurturing promising scientists and pro-efficient technicians and professionals in Science and Technology.

*“We learn how to do things by doing the things we are learning to do”*

*(Aristotles)*

## **Acknowledgements**

The author as co-ordinator of the network would like to acknowledge commitment of all Members of the network. We also acknowledge the support of the European Commission under the Socrates Project n<sup>o</sup>. 110157-CP-1-2003-1-PT-COMENIUS-C3.

## **References**

- [1] Costa MFM, The importance of experimentation on teaching the basics of optics at elementary and high schools, Proc. Soc. Photo-Opt. Instrum. Eng., 3190: 228-232, 1997.
- [2] Kolb DA, Experimental learning: Experience as source of learning and development, Prentice Hall: Upper Saddle River, 1984.
- [3] Gatt S and Vella Y, Constructivist Teaching in Primary School Social Studies, Mathematics, Science, ICT and Design and Technology, 2003.
- [4] Christian W and Belloni M, Physlets: Teaching Physics with Interactive Curricular Material, Prentice Hall's Series in Educational Innovation, 2001.
- [5] Michaelides PG, An affordable and efficient in-service training scheme for the Science Teacher, in Proceedings of the International Conference Computer Based Learning in Science, pp.: 792-799, 2003.
- [6] [http://folk.uio.no/sveinsj/ROSE\\_abstract.htm](http://folk.uio.no/sveinsj/ROSE_abstract.htm)

---

Paper presented at the 1st International Conference on “Hands on Science. Teaching and Learning Science in the XXI Century”,  
Ljubljana, Slovenia, July 5 to 9, 2004.

---