European summer school for primary science trainers
Erice, Italy : 9-14 July 2005

Proceedings

plenary sessions abstracts
workshops testimonies and reports

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Introduction

Over the last decade a renovation of science education has been launched in a number of countries; for example: USA - *Hands-on*, France - *La main à la pâte*, Sweden – NTA, and China - *Learning by doing.* These renovations have been strongly supported by the Academies of Science and the scientific community in their respective countries and have been based on the principle of an inquiry-type teaching (building of hypotheses, experimentation, team-work and written expression). The renovation of science education has already achieved substantial results but it also requires a major effort in teacher training, provision of resources, and educational research. Quality teacher training is the key to the strategic development of science education but the current number of qualified trainers in Europe is grossly insufficient.

Within the framework of the European project *Scienceduc*, the **European summer school for primary science trainers**, hosted by the Ettore Majorana Centre for Scientific Culture (Erice, Italy), was devoted to the topic of science teacher training. During this summer school, a common basis for the discussion of hands-on teaching and teacher training at primary and kindergarten levels was developed, ideas about good teaching practices were exchanged, and recommendations for the organization of quality teacher training at European level were developed.

Each day was dedicated to a key issue:

> Sunday 10th of July:
> The inquiry-based method in primary schools: process steps, teacher's role, and elements common to European teachers
>
> Monday 11th of July:
> Teacher training in inquiry-based methods: introduction and requirements for implementation
>
> Tuesday 12th of July:
> Tutoring devices: coaching and training
>
> Wednesday 13th of July:
> Evaluation and research: the process of evaluation, neuroscience and education

In the morning, conference presentations and panel discussions were scheduled according to the themes. In the evening, workshops related to the morning presentations were led by experienced science teacher trainers.

Our goal in promoting science education is not to increase the number of future scientists, engineers or technicians (although this may be a beneficial consequence), but rather to develop moral qualities such as the understanding and respect for the truth, the respect for others, and the humility in face of facts and other people's points of view. The understanding of the real nature of science is at the centre of the proposed model of science education through inquiry; science is not an accumulation of facts or knowledge; it is a process of approaching and questioning the real world. Understanding that science is a domain where what is true, false, likely or unlikely can be distinguished helps to clarify the child's view of ethics. Science skills (vocational, citizenship, health, nutrition) are essential for all humans to become active citizens of the 21^{st} century.

This summer school was a unique opportunity for European primary science trainers to formalize their understanding, share their experience, and improve their knowledge of inquiry-based science teaching.

The inquiry-based method at primary school: process steps, teacher's role, common process elements to European teachers

Plenary conferences 1

Chairman: Yves Quéré, Académie des sciences, France

What is our feeling about science?

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Before teaching science, we should clarify our views about it. In particular, we have to address the following three questions – *Is science open or closed ? Easy or difficult? Good or bad?* – and, if possible, be able to offer some answers.

Contrary to a belief spread in the 19th century, when science was considered to be practically "finished", it is clear now, to any scientist, that each discovery opens un-envisaged new fields of research. Everything happens as if knowledge was like a precious nectar poured into an amphora, each new drop increasing, of course, the contents and, at the same time, enlarging the container, in a kind of endless arborescence: science is a wide open field of knowledge, which will probably never be contained within a closed horizon.

Science is like a high mountain (Everest?) to the top of which only a very few highly specialized people are able to go. But many well-trained people can climb Annapurna (8000 m), many more can climb Mont Blanc (4800 m), and everybody is able to walk in those nice hills around the Alps : the continuity is such that everybody can find a suitable altitude. Science provides the same opportunity to reach – according to one's talents and training – a given level. There is nothing like an initial gap which must be overcome before entering into science: one must simply wish to walk and enjoy the walk.

Does science spread evil (weapons of all kinds, pollutions...) among societies and individuals, more than it does good (healthcare, communications...)? This question – unthinkable a few decades ago – is nowadays a subject of discussion, at least in industrialized countries. Children should be taught from an early age that science, and more generally knowledge, is immensely beneficial for humankind; that citizens need to be aware of all potential dangers which it may create and be ready and capable to engage in democratic debate on these matters; and that this should be done with good understanding, an unfounded application of the principle of precaution having potentially significant harmful consequences.

Erice 2005
Plenary session 1
July 10

The role of literacy in inquiry-based science teaching and learning

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A growing body of research and experience suggests that how students use oral and written language during their scientific inquiries should be of critical concern to teachers as they support the development of students' scientific reasoning and conceptual understanding. Yet frequently what is called 'hands-on inquiry-based teaching' includes little of the thoughtful and challenging discourse, writing and reading that is fundamental to student thinking and, ultimately, the development of understanding. Clearly oral discourse, writing, and reading are always present in the science classroom. The question this presentation addresses is whether the language which students are using and how they are using it is serving their science learning and what the implications are for teaching.

The presentation is structured around the consideration of three basic areas of literacy:

Oral discourse and writing as tools for clarifying and deepening understanding of an idea/concept; sharing, defending, and debating ideas in a group; and collaborating effectively; and reading as a tool for extracting information from texts; experiencing the ideas and works of others; considering and critiquing various points of view; and extending one's own ideas. In each of the three areas, the focus is on selected moments in student direct investigation when oral and written language is particularly important and requires sophisticated guidance from the teacher.

The discussion of oral discourse focuses on large group discussions for the purpose of gathering and taking stock of ideas, planning an investigation, and developing conceptual understanding. While all require basic discussion skills, the different purposes make different cognitive demands and lead to somewhat different structures. Effective participation in science discussions requires that teachers create a community of science learners in which these discussions take place, and for students to develop the abilities to use a variety of discourse skills.

Writing is a way for children to think and clarify ideas as well as to communicate with others. The discussion of writing begins with the assumption that writing is intimately connected to talking and that talking is intimately connected to having experiences and thoughts. Writing comes from talking and extends talking. If children have no experience, they have little to talk about; if they cannot talk about their ideas they are unlikely to be able to write about them. When children document their observations, think about how to organize their data collection, synthesize their findings and state their ideas clearly, they have to understand more clearly and more deeply what they are doing.

Children use writing in many ways in the science classroom. Two that require careful teaching and guidance are the science notebook – the on-going, written record of action and thought – which is written as an investigation unfolds; and the more formal report and/or presentation that communicates final claims or conclusions, evidence, ideas and new questions, all drawn from investigations.

The connection between science and literacy also includes reading text in many forms (e.g. electronic copy, journals, books). It is of particular importance that students learn to use secondary resources to support their investigations and their emerging ideas and do not learn to read for the exclusive purpose of looking up facts and information. For teachers this means teaching and guiding students to use text as an element of inquiry and as an object of inquiry and not just to gather information.

Learning science in elementary school

The development of scientific concepts and the influence of everyday knowledge when learning science

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In education, not much importance has previously been given to valorizing the professional development of teachers, including pre-school teachers. Teacher training is an important component of any proposal for the development of the educational system. For this reason, the challenge facing teacher trainers is enormous (Fullan, 1995; Fullan *et al*, 1992; García, 1999; Guskey *et al* , 1995).

The way in which teachers teach, what they teach, how they explore scientific contents, and the scientific development with which they provide their students from early on are very important aspects to be considered (Harlen, 1997). However, it is also important to analyze curriculum and textbooks, as these influence – sometimes in an obvious and direct manner, at other times more subtly and indirectly – the pedagogical practice of teachers in the classroom.

Communication describes the part of the study aimed at investigating the relation between the program/curriculum, the textbooks and the teachers' pedagogical practice with regard to two aspects: (a) the conceptual development they allow and (b) the relationship established between scientific knowledge and common sense knowledge. These two aspects are central to analyzing and reflecting on the level of learning and scientific literacy which is being given to children.

The investigation was developed at primary school level and was based on, as mentioned, the program/curriculum, the textbooks and the teachers' pedagogical practice. It was oriented towards responding to the following issues: (1) Investigate suggested conceptual development; (2) Investigate the relation between scientific knowledge and established common sense knowledge; (3) Identify continuities and/or discontinuities between the aspects being analyzed; (4) Reflect on the consequences of identified continuities and/or discontinuities; (5) Reflect on the implications of data at teacher training level.

The methodology used was an interpretative analysis of program/curriculum and textbooks and an analysis of video recordings, transcriptions and field notes of primary school pedagogical teaching practice.

Instruments were constructed in line with the theoretical conceptual frameworks on which the study was based and adapted from instruments described by Morais *et al* (1993, 2000), which in turn were based on Bernstein's theory concepts (1990, 1996).

Results suggest that: (1) the program/curriculum, and especially textbooks, point to a superficial exploration of topics at times and that the promoted scientific learning seems to be centered on terms and facts. With regard to the teachers, data is distinct; some teachers develop high conceptual levels in their teaching units whilst others just explore the scientific facts and terms; (2) Although the curriculum focuses on the importance of valorizing the common sense knowledge brought by children, it does not include explicit suggestions to do it. In relation to the textbooks, the situation is more serious: several books develop scientific knowledge in such a superficial way that it may be confused with common sense knowledge. With regard to the teachers, the data shows that they have some difficulties, although this applies to some more than others, in establishing the relation between scientific knowledge and the common sense knowledge brought by the children; (3) There is some continuity (undesirable), between what program/curriculum, textbooks and pedagogical practice developed by some teachers at the low-level scientific conceptualization and the non-relation between the different types of knowledge (scientific and common sense). The discontinuity (advantageous) has to do with the pedagogical practice of some teachers who, fortunately, implement higher conceptual levels than those which are found in textbooks and in the program/curriculum; (4) Considering that the program/curriculum and, more obviously, textbooks in some way influence **what** and **how** the teachers teach, we are left with some concerns with regard to the scientific development they offer primary school students. Learning can be reduced to the acquisition of names/terms without any sense or connection to day-to-day life; (5) We have to rethink teacher training so as to raise the conceptual awareness of teachers, give more meaning to students' learning and, in short, raise the level of the children's scientific literacy.

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Scienceduc: renovation of science teaching
in European primary education with inquiry-type methods

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In a number of countries, a renovation of science education has been launched in the last decade on the basis of an inquiry-type teaching method (USA, Hands on, France: *La main à la pâte*, Sweden: NTA, China: Learning by doing….). This renovation, which has widely given substantial results already, requires major efforts in Europe on teacher training, resource elaboration and educational research.

Scienceduc is a project financed by the European Commission which focuses on the renovation of science teaching by inquiry-type methods at the European level. The main objective of the project is to disseminate the best methods, techniques and practices in science teaching in primary schools through the establishment of a European network within the framework of the formal education system. The project was proposed by Estonia (Tartu University), Hungary (Apor Vilmos Catholic College), Sweden (NTA- Royal Swedish Academy of Sciences), Portugal (Ciência Viva) and France, the project coordinator (*La main à la pâte* : ENS - Académie des sciences - INRP). All of these countries have a solid educational background.

The promotion of science education is devoted not only to increasing the number of future scientists, engineers or technicians but also to developing in children moral qualities such as understanding and respect for the truth and respect for others.

The project actions, scheduled over 2 years (November 2004 – October 2006), are focused on 5 different topics:

- **Teacher training*:*** This consisted in the organization of the current International Summer School for Primary Science Trainers in Italy, in July 2005. During this summer school, the common basis for hands-on teaching and teacher training at primary and kindergarten levels will be defined, exchanges of good teaching practices will be carried out, and recommendations for the organization of quality in-service training at European level will be provided.
- **Evaluation:** A European database on the effects of hands-on practices at primary school is being implemented.
- **Dissemination of good practices and methods** will allow the education program to be extended to new primary schools. Seven national conferences will be organized about primary science teaching in 2005 and one European conference will be organized in 2006.
- **On-line collaborative project:** This consists in the implementation of an online trans-disciplinarily project about science and history, “The European Discoveries” http://www.inrp.fr/lamap/mapmonde/europe

Scienceduc actions are integrated with other European actions, especially those carried out by Nucleus, a cluster of European educational projects. Research results are published on the Nucleus portal (http://www.xplora.org/ww/en/pub/xplora/) and in the new ESTI science education journal.

Scienceduc perspectives

- Contribution to European Union objectives: "…Europe should become a worldwide reference for the relevance and quality of education, specifically on science teaching…"
- Promotion of contacts between education actors and scientists in order to improve the understanding and practice of science and technology by European society.
- Promotion and support of European educational centers of excellence as a reference for pedagogical practices.
- Promotion and support of educational research.

The inquiry-based method at primary school

Process steps, teacher's role, common process elements to European teachers

Workshop 1

Issues:

Definition of common elements of the inquiry-based science teaching: principles, process characterization, process introduction into the classroom, specificities of life science teaching, physics and technology teaching and early childhood teaching.

Hands-on teaching process for life science

Workshop chairmen: Peter Rockel and Fenita Dyckerhoff
Science Lab, Germany
Reporter: Miquel Angel Alabart
PAU education, Spain

The conductors introduced their work in Science Lab., a company that organizes extracurricular science activities with a hands-on approach which encourages children to ask questions and use experiments and models (www.science-lab.de).

A class simulation was proposed using a role playing technique. The chairmen encouraged the participants to ask questions; they later showed a model which is used to teach how an eye works. During this activity there was a debate about what inquiry activities are, under which conditions they can take place, and about the use of models in life science teaching.

In their presentation, the conductors also showed the conceptual map as a tool for providing a graphic representation of all of the concepts related to an interest topic and their relations.

Finally, the participants learned about various materials that Science Lab uses for their sessions and experimented with them.

From all the discussions and experiences, the main conclusions that could be extracted are:

- Stages: It is important not to over stimulate children with overly complex or abstract concepts. Activities must match the children's level and interest.
- It is important, when possible, to go directly to the real object. In life science this is very often impossible due to the problems inherent to working with the human body or dead animals; one of the resources is models.
- Models should, if used, be the last part of a long sequence of questioning, hypothesizing and observation/experimentation (inquiry) activities. Radiographies, ultrasound images, and graphics, among others, are valuable life science resources with strong links to reality.
- An important difference between biology and other sciences is the need to deal with many variables most of the time. This means that observations are very important. We must observe different things depending on what is being investigated, so observation becomes an important skill which must be taught.
- Another important particularity of biology is that, since it is related to life, it is related to the children's lives and their environment, to health and ecological issues, and to responsibility and citizenship in the children's everyday lives.

Teaching inquiry-based physics in the primary school

Workshop chairman: Tina Jarvis
Science Learning Centre East Midlands, UK
Reporter: Isabelle Duvaux-Béchon
ESA, France

Physics inquiry curriculum

When reviewing physics curricula, it appears that they are very different from one country to another: some countries have a very developed one that started more than 10 years ago, while some others are only now in the process of integrating the discipline. Having physics in the curriculum does not, however, mean that it is done in the classroom.

In the countries that have just started the process, teachers are not yet been trained, meaning that it will take some time before the majority are able to implement it in the classroom.

Apart from the curriculum itself, some countries have experience in inquiry-based methods while others do not.

In cases where science and physics do not yet form part of the curriculum, there is, however, a tendency to base teaching on inquiry methods, although this is developing very differently from one country to another. Even if it is compulsory, many, if not most, teachers are not confident and many do not practice it at all.

Advantages and disadvantages of inquiry-based tasks for physics

Unlike many biological investigations, a whole investigation can be completed within the time available in the primary class. It seems easier to define and fix variables in physics than in biology, where to fix all parameters seems to be more difficult. Chemistry would also be easier but the microscopic level at which explanations should be given makes it too difficult for primary. Simple investigations can be given to very young children.

The main problem for teachers seems to be the concepts, namely understanding them and feeling at ease working with them in the classroom. Teachers are not at ease with physics and feel more secure with biology.

There is also a problem in the change of routine to an inquiry-based one. It should be a way of teaching science which does not overlook observation (of plants, animals or stars).

The trend of considering biology as a good science and physics as a bad one should also be avoided. It is advantageous to include physics inquiry in the classroom in order to give a more positive view of physics.

Some discussions have been held about ‘what is inquiry?’ or ‘what is investigation?’ (the definitions and understandings vary from one person to another). In addition, there are inherent differences between inquiry in physics and in biology.

Two objectives were identified for inquiry-based work:

- Do research
- Give students the ability to develop independent research work

Many problems or concerns have been identified. (These have not been sorted by importance but are listed as they were expressed):

- How can an experiment be made didactic?
- What do we want to be the outcome of inquiry?
- It is not important to decide if physics is the best – it is one method that can be used
- What makes a good inquiry proposal (control of variables)?
- It is very difficult for children to break down their very general questions into 'simple' questions so that inquiry can begin
- Teachers have to recognize what an inquiry is and what can be done

More generally, the fact that a subject forms part of a curriculum does not mean that there is content attached or that it is applied the right way. We have now to ensure that it is applied and that there is enough investigation to promote the active behavior of the pupils.

It would be interesting to give examples of mistakes to be avoided.

It has been recognized that when questions or problems come from the children themselves, from their perception of the world, they tend to be more engaged and more enthusiastic than when the question or object of study comes from the teacher alone.

Technology curriculum

This is not always considered as a separate subject but technology problems are quite popular for raising/attracting interest. Technology provides a relevant context for science learning, a context for controlled investigations (e.g. testing conductors and insulators for use in switches), and develops pupils' problem-solving skills. It could be a starting point but does not really seem to be inquiry as such. Pupils and teachers may focus on the making and doing and ignore the science ideas. It may be difficult to match the level of the science concepts needed by the pupils and the activity carried out. Engineering could be convenient even if it is not in the same domain. Teachers have to know what they are doing and for which purpose.

Disadvantages can be reduced by heightening teachers' awareness of the issues and by providing training.

Providing a structure for investigations to promote pupil independence

A chart was presented for discussion. It included cues to guide pupils in their use of variables through an investigation based on ideas (in "Making Sense of Primary Science Investigations" by A. Goldsworthy & R. Feasey Revised S. Ball, 1997, ASE)

Children have to learn how to ask "why"? If there is no testing, there is no science.

Whatever the question or exercise, answers it can be obtained at different levels and depths according to the age and ability of the children. The teacher should adapt the work proposed. In order to develop a progression, teacher may, for example, propose to make simple comparisons using observation rather than complex measurements as well as using measurements and graphing to explain phenomena. Planning is important for the teacher in order to give independence to pupils progressively, by initially directing all stages of the investigation then making part of the investigation open-ended, for example by allowing a choice of equipment or method of communication, and by finally making the whole investigation open-ended.

The examples given seem to indicate that inquiry methods make better students, who 'think better' and have fewer difficulties than others when going in that direction.

There is also a generation effect: we should, preferably, act on future teachers as they do not yet have years of habits to be changed. In–service training is more difficult and time-consuming. Training can be easily implemented at times when the curriculum changes.

How can teachers be persuaded to change?

In at least one country, 'good' teachers (identified by their supervisors) are given higher salaries…

Training several teachers in the same school could have beneficial effects in that teachers would not feel alone and children would have the opportunity to do inquiry for several years. (A single teacher is not enough to change the mentality).

Science teaching process for pre-school

Workshop chairman: Karen Worth
Education development Center, Inc., USA
Reporter: Margarida Afonso
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The group included quite different participants with different professional backgrounds, who shared a common interest in knowing how we can better explore science in the pre-school context.

The workshop focused on one topic – discovering nature – as a vehicle to explore the structure and ideas behind the "Young Scientist Series" Program of the Education Development Center. This is a program for teaching science to children aged three to five. It is designed to guide teachers in using some of the basic materials and centers of the early childhood classroom as objects and places for serious scientific investigation. It is based on a fundamental belief in the ability of very young children to engage, at their own level, in extended science inquiry.

The discussion began with what is meant by 'early child' and why science for young children is important: children are curious, children naturally undertake scientific inquiry, children are used to developing explanatory theories, and science usually engages *all* children….. The choice of subject is very important: the subject should be developmentally appropriate for direct exploration and should be open to deeper exploration over time. It should be interesting and engaging and must built important scientific concepts.

Physical characteristics of living things; basic needs of living things; simple behaviors of living things; life cycles of living things; variation and diversity among living things; and relationships between living things and their environments could be seen as examples of Life Science areas which are accessible to young children.

The workshop discussion was centered on the process (or processes) to be developed in the pre-school context:

1- How important are questions?
2- What comes after the children's questions?
3- How important is the process?
4- What is included in the process?
5- What is more important: the contents or the investigative skills?

The main conclusions are:

1- It is important and possible to explore science in the early years. Children should be encouraged to develop different skills: posing questions; exploring objects, materials, and events; making careful observations; describing, comparing, sorting, classifying order. A variety of simple tools may be used to extend observations and to engage children in simple investigations. It is possible for them to record observations; to give explanations and ideas; to work collaboratively with others; to share and discuss ideas; and to listen to new perspectives.

2- To improve science teaching processes in pre-school it is important to find patterns and trace some global/general roots.

3- It is important for young children to represent their work in many ways and for teachers to use this work with children.
In order to deepen children's understanding, teachers should engage children in conversation as they work, lead group discussions, and encourage children to document and represent their work as well as documenting what is happening.

4- "A Shift in Emphasis" in science teaching was proposed: scientific ideas, theories, and the process of inquiry need to be given more emphasis than scientific facts and information. We should place more emphasis on science experiences in the classroom and the community than on science experiences that occur only in the classroom. We should prefer to work on months-long science investigations of developmentally appropriate concepts rather than on weekly science themes/topics. In early childhood classrooms, science notebooks, documentation panels, and children's work and drawings should replace experience charts.

5- We must have more emphasis on science inquiry and less on science-isolated activities (although some different conceptions of "science inquiry" appeared in the workshop).

Teacher's training on inquiry based method: Introduction and requirements for process implementation

Plenary conferences 2

Chairwoman: Karen Worth, Education development Center, Inc., USA

Science training for primary school teachers in France

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Teacher training in France should be very easy to present as it depends on one ministry, one national curriculum, and one authority. However, despite this high-framed system, it consists of a large range of diverse policies based on local authorities and decisions. In order to understand our action, it is, therefore, crucial to have a brief introduction to the French educational context and especially to professional development aspects.

Basic education in France involves more than 57 0000 primary schools and 281 000 classes for children from 3 to 11. Primary school teachers are polyvalent, mostly women (80%) with a literary background (75%), recruited at graduate level since 1991.

School contents are defined through a national curriculum which prescribes 2 to 3 hours of science weekly. Despite these recommendations, a survey the Ministry of Education conducted in 1995 showed that science was being taught in just 3% of classes in kindergartens and primary schools. This reflects the extent to which teachers dread having to teach a subject which they consider too difficult. Science has undoubtedly made dizzying progress but teachers do not realize that the basic concepts they should teach have not changed.

La main à la pâte initiative was launched in France in 1996, thanks to Professor Georges Charpak, Nobel for Physics 1992, and the French "Académie des Sciences". It aims to promote scientific investigation within the framework of primary school education. It benefits greatly from the active support of many scientists. By prompting pupils to use argument, whether oral or written, this process contributes to language learning and to acquiring an independent attitude that is heedful of others. It is based on teachers' achievements, skills networking and synergies with external actors, inspectors and educational advisers, college of education training staff (IUFM), specialists in science teaching, scientists, engineers, and science students from universities or national colleges ("Grandes Écoles"), as well as parents.

La main à la pâte, first launched in 344 classes, has been extended progressively to thousands of classes. In 1998, an Internet site was created to provide an opportunity for exchanges between teachers and scientists and to propose a number of resources (www.lamap.fr).

In June 2000, the French Ministry of Education set up a plan to renovate science and technology teaching at primary school in order to spread the acquired expertise of "*La main à la pâte*" to all schools. The plan, independent from the initiative itself, integrates it as an innovative pilot project. In September 2002, a new science curriculum was published in accordance with the French ministry plan and recommendations from *La main à la pâte.*

An institutional framework promoting hands-on activities does not mean that all teaching staff will become at ease in science teaching. Teachers are still afraid of doing science through active pedagogy. Changes in teachers' attitudes toward science and their classroom role require major efforts, especially on teacher training.

In France, pre-service training is organized over 2 years through a college structure called IUFM (www.iufm.fr/f_qu-iufm.htm) and based on Ministry of Education instructions. It consists of 1 year of exam preparation, a regional recruitment exam and 1 year of professional development. Students selecting the science option for the recruitment exam will follow a 60-hour science course during the first year. Other students will follow a 40-hour science course during the second year. Despite a strong willingness to reinforce science education in primary schools, it is surprising to note that science courses have decreased over the last five years. It seems that IUFM gives priority to the polyvalent approach and is planning to include science as a mandatory subject for recruitment exam.

In-service training is no longer the responsibility of IUFM and now depends on Ministry of Education inspectors. Training can be conducted by IUFM but also by other educational actors, for instance directly by Ministry of Education officers, GNO, or the scientific community. There are three training levels for teachers: national training sessions (for resource personnel and supervisors – scarce science stages) generally lasting 1 week; regional training sessions lasting 1 to 4 weeks; and county training sessions providing at least 12 hours of mandatory training per year (for all fields).

Teachers are facing heterogeneous landscape: a broad diversity of offers with different training modalities (variety in terms of duration, content and approach), different kinds of trainers with undefined orientations, some logistical constraints (finding teachers to replace trainees, obtaining authorization from local educational authorities), and no any educational constraints (no obligation to be trained, apart from the county training plan, no commitment, no evaluation, etc.).

It is, therefore, tricky to establish a coherent training strategy targeting all teachers except at local level, where priorities are decided by local educational authorities. Since 1996, *La main à la pâte* has tried to change the situation smoothly, dedicating part of its activities to teacher training. Some basic principles for trainers has been established and diffused. Ex: "to train teachers as children will be taught". Based on this first practical approach, the teacher can discuss different aspects of the transfer to class and the inquiry approach, explore materials and acquire scientific concepts. It is advisable to count on the presence of invited scientists during training session, to organize a post-training follow-up and to involve trainees in resource implementation and production (class sequences, books, Websites, etc.).

To convert institutions (e.g. IUFM, the Ministry) to this training approach, *La main à la pâte* implemented a IUFM trainers' network in 2000, under which one correspondent per region acts as relay for all *La main à la pâte* activities. Several national and European meetings for trainers have been organized since then, a guide for trainers was published by the Ministry of Education, an online expert network has been implemented, a website devoted to trainers is in progress, and a yearly one-week meeting "Graines de sciences" ('Science Seeds') is organized. Since 1998, it has brought together 30 teachers and 8 high-level scientists to introduce teachers to the pleasures of scientific practice (and not only for teaching!). During this training, each scientist leads an informal 3-hour workshop related to his/her research subject and, after the session, scientists and teachers write the “Graines de sciences” book together. These examples show that we need to be imaginative and original to make the system evolve.

Teacher training and coaching is the main issue for generalization but we have to keep in mind that, in France, training and follow-up depends on humans and not on structures (the status of the resource personnel is renegotiated annually). Trainers’ and teachers’ autonomy makes it difficult to have a global long-term strategy of training content and quality control. To reform science education, we need political willingness and support, a definition of common principles, a coherent long-term policy, and the collection of high-quality resources for trainers. In this scheme, scientists can play an essential role by accompanying teachers, contributing to training, and taking part in writing “official” books for teachers and for trainers.

Ten years of activities have already produced some encouraging effects: the number of classes where sciences are taught in French kindergartens and primary schools had climbed from the initial 3% to 35% by 2004. If we consider a linear scale, we can expect to involve the whole system in 20 years to follow an exponential (fast) track; we hope that international and European interaction will help us to increase the slope of the curve!

The NTA program
The Swedish model for in-service training

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The NTA program (www.nta.nu)

The aim of the NTA program is to support teachers in their effort to stimulate children and young people's curiosity, interests and knowledge in science and technology, to inspire and support local efforts to better achieve the goals of the national curriculum and syllabuses by developing methods to improve local teaching and learning and spreading them to municipalities and schools. The NTA program has two divisions: ***NTA P&S*** *(NTA Production and Services)* and ***NTA R&D*** *(NTA Research and Development)*.

NTA P&S provides curriculum units consisting of guides for teachers and students, experimental materials and services, professional development programs, e.g. training for NTA trainers, seminars and conferences for NTA co-ordinators, follow-up and assessment of units and services, and marketing of the NTA program.

NTA R&D adapts, improves and develops new and existing units on the basis of research and the experiences of teachers and students participating in the NTA program.

A research program is being designed for practice-oriented research in educational science, using the NTA program and the participating municipalities as a research arena.

Professional development programs in the NTA Program

Continuous professional development for teachers

Every teacher using a unit completes one day of training in that thematic area. Teachers are also given repeated opportunities to share their classroom experiences. Professional development is also carried out in collaboration with local educators (experienced teachers), industry, colleges and universities.

The one-day unit training involves teachers gaining an understanding of an NTA unit through work with the unit assignments (lessons), consideration of didactical issues, and emphasis on observation, reflection and documentation as development tools.

University courses

In collaboration with the Stockholm Institute of Education and Linköping University, a 5+5 point university-level course, entitled Science and Technology, was conducted.

The Department of Physics of Stockholm University initiated a partly web-based, 5-point course entitled “Physics – how things work” in 2003; the course is aimed specifically at NTA teachers.

During 2003, Linköping University conducted a university course specially designed for NTA teachers. The teachers studied the scientific concepts and phenomena built into the NTA units.

The Leadership Institute for NTA trainers

The Leadership Institute for NTA trainers require four days as well as time for reading, working and planning. The goals of the course include: understanding why schools teach science and technology, understanding the role of experiments, acquiring deeper knowledge of and insight into the NTA concept’s basic ideas and qualitative aims in relation to the national curricula and syllabuses, and understanding the issues of adult education.

Another important focus of the seminars is to deepen the understanding of the strategies to improve professional development for teachers locally in each municipality.

Teacher`s training on inquiry-based method

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Teacher training for science teachers (both in-service and pre-service teachers) in the guided inquiry-based method in the primary school has definite goals and is mainly focused on two targets:

1. to introduce teachers to the fundamental ideology of the inquiry method and to gain practical experience in classroom
2. to give basic knowledge in science to those teachers who have not followed advanced courses in science (class teachers, primary school teachers).

The new paradigm of learning and teaching that forms a fundamental concept in the inquiry program for primary school and kindergarten studies requires a very serious change in school practice. In the past, schooling was mainly oriented to acquiring lower-order cognitive skills and teachers, with their old-fashioned training, were prepared to fulfill the requirements that were laid upon them. Today, schooling has to meet new standards of learning and teaching, the main goal of present studies being the acquisition of understanding that will lead to the formation of higher-order cognitive skills such as problem solving, critical and systemic thinking, questioning, creativity and social adaptation. The meaning of the term "knowledge" has shifted from the old definition of "to memorize and repeat facts" for getting good marks at school to the info-society definition of the term that says the "knowing" nowadays means "finding, and knowing how to use, the information needed".

This conceptual shift in the understanding of the main goal of the learning process must also be understood by teachers who are going to fulfill the needs of modern society and are going to prepare students for their life-long studies, giving them the keys to being interested in science, to being interested in the processes that surround us!

Teacher's training on inquiry based method:

introduction and requirements for process implementation

Workshop 2

Issues:

The inquiry based process in science - implementation of training sessions in European countries: Are classroom simulations required? What are their limits? How to proceed: should one move from process to contents or from contents to process?

Training process

Workshop chairwoman: Karen Worth
Education Development Center, USA

Reporter: Alberto Ferro
Instituto Superior Técnico, Portugal

The workshop topic was introduced by Karen Worth from the Education Development Center, USA. The first testimony was produced by Sophie Hulo from Geneva University, Switzerland. She reported on recently-started in-service training of Geneva University. The program started in 2003 as a collaboration between the university and the state education department. Three or four two-day sections were carried out, enrolling 200 primary teachers (around 20% of state department teaching population). Besides this continuous training process, specific events with wider public participation were carried out. These events were designed with a scientist, a student, a teacher and a media component. Special attention was given to "Clim@tic", a scientific and pedagogical project that will start in 2006.

The second testimony was produced by John Cripps from Deakin University (Australia). He started with a round table to provide workshop participants with contact with the pre-service training of teachers in different countries. Case studies from England, the USA, China, Germany, Portugal, the Netherlands, France and Sweden were given.

The diversity between countries and in some cases, inside each country, was stressed. Although some differences exist, the time dedicated to science is limited, going on average from 40 hours to 60 hours. In addition, it was emphasized that, in many cases, the student teacher can choose biology, chemistry or physics.

In most cases, university courses are typically followed by one year of in-service training with a tutor. The tutor is a primary school teacher and the university has no control over this tuition. It was also stressed that in many cases, and in particular relative to classroom practice, student teachers care more about the advice of the tutor than university learning.

After the discussion period, John Cripps returned to present Deakin University practice in science teaching. The model presented was different from others. Student teachers' science education was carried out in the primary school. Typically, a class of 30 trainees was brought to the school for a period of 4 hours for 9 to 10 weeks. Trainees had 3 hour classes and 1 hour of interaction with a group of 5-6 children (the same throughout the 9-10 weeks). During the interaction, the group of children would carry out science experiment activities.

A general discussion about the evaluation of in-service training regarding inquiry-based teaching methods also took place. The majority of participants expressed their desire to have tools which assess the impact of their practices among teachers and in classroom. Others stated that there is no place for evaluation, and that support for inquiry-based teaching should be considered from a philosophical point of view.

Scientific education by immersion

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"Penser avec les mains" is a pedagogical Swiss project led by Geneva University. The aim of this project is to reinforce scientific education at school using two different approaches. The first one consists of lifelong learning in the science education of primary school teachers. The second approach consists of original and stimulating scientific events, such as Clim@TIC, giving science a human face. Clim@TIC is a project on the management of environmental change and sustainable development. This pedagogical event will begin in 2006 in Swiss schools. It proposes a global approach to environmental subjects such as climatic change or deforestation.

School-based delivery of science education for pre-service teachers

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Pre-service teacher education in science delivered through a school-based program has proven to be effective in inducting students into a community of constructivist practice at Deakin University. This presentation reports on the evolution of the program, an Action Research project, and the problems and opportunities encountered. Aspects of the course have been the subject of research, in particular, an Action Research project undertaken to investigate the way sessions are organized.

A number of surveys have shown that this program is popular with students. Lectures, workshops, tutorials, discussion, assessment, and feedback were tied together by the teaching which students undertook with small groups. The program has proven successful in that it placed the knowledge, skills and values that were taught within the context of the school where participants could immediately implement what they had learnt.

Resources for trainers

Workshop conductor: Nicolas Poussielgue
Ministry of Education, Senegal
Reporter: Pasquale Nardone
Free University of Brussels, Belgium

A number of points of consensus emerged from our discussion.

- The training process needs to go through different steps

  back and forward from classroom to training center
  back and forward from theory to practice
  back and forward from pedagogy to science
  back and forward from science centered questions to society

- The training approach
  - Classroom simulations are essential: trainers put teachers in classroom situation with experiments and discussions.
  - An inquiry-based approach is needed to train teachers and help them to ask all questions, to open their minds to all possible remarks, to be able to express freely their misconceptions and social fears.

- Resources

  A website has been temporarily implemented in order to collect and share documents for trainers: http://formalamap.free.fr. It offers different ready-to-use resources for trainers and a web-based application for video analysis of real classroom situations linked to an online discussion. This website is a prototype of a future website for trainers hosted by “La main à la pâte” website (www.inrp.fr/lamap).

- Practices

  Different practices appear from “classical” training process from specific centers or universities (according to the country) to special project which shows “science training” in action involving different classes or even different countries: international collaboration for working a specific topic, to carry out national scientific challenges…

First scientific and technical challenge in Meknès

« Stories of water: dirty water, clear water, drinking water »

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From March 28th to April 2nd, 2005 and for the second time, the Science Week took place at the French Institute in Meknès. During this meeting, nine 5th and 6th grade classes from Moroccan private schools exhibited works undertaken during the First Scientific and Technological Challenge. This event, organized by the French Institute, allowed the presentation of the challenge concept to Moroccan teachers as well an introduction to the "Hands-on" inquiry method.

Three steps were necessary to set up the challenge:

- A teacher training session in October, 2004 to present process, didactic and pedagogical objectives;
- Follow-up actions carried out by a trainer in February 2005 including a daily visit to classrooms to continue teacher coaching (approach and practical tips);
- A meeting of classes for Challenge purposes followed by teachers' progress report.

Despite difficulties related to the Moroccan education system (standards segmentation, teaching time, diversity of teachers' background, equipment availability…), projects were carried out entirely with a highly enthusiastic investment on the part of students and teachers. Clever solutions were found in order to achieve objectives, including group work by French and science teachers and the implementation of after-school science workshops.

The clean water thematic (related to current problems in the country) allowed pupils to acquire scientific notions such as homogeneous and heterogeneous mixtures, decantation, filtration, vaporization, distillation. The water cycle, treatment and water supply in Meknès were also studied. The "Hands-on" approach that first aroused teachers' enthusiasm during the training session enhances pupils' methodological and linguistic skills. Bibliographic research of documents (using the Internet and books), observation, modeling, and visits to water processing stations or water towers, drove students and teachers in this exciting work.

During the Science Week, pupils explained to the jury how they acquired teamwork and listening skills: it is important to take account of other children's points of view. They also explained that agreements and collaboration with other children were needed to perform the experiments and build models.

The experiment book redraws the different project steps. It contains the different types of writing, reflecting individual work, group work and teacher suggestions.

Finally, the challenge promoted communication: As one teacher said, "Our students wanted to write, to explain what they were doing…". In some cases, teachers took the initiative to write letters to the RADEM manager in order to organize a visit to a water processing station.

The challenge enabled the Moroccan students to improve their writing skills (through the experiment book) as well as their oral language skills in French, thanks to exchanges and debates, among others.

They designed posters, illustrated by drawings, diagrams and comic strips, which showed the story of 2 drops of water – a dirty one and a clean one – that meet each other. Children exhibited their work during class meetings: they described their models of the water cycle, and spoke of purgation station and water towers. The event finished with a trivia game which allowed participants to test their knowledge.

In addition, work about water problems motivated students to discover and write advice and slogans to fight against waste and for the protection of the environment.

Some of the students were really excited by collaborative work and by discoveries shared, while other enjoyed meetings…this was an occasion to keep wonderful memories of the event!

Winning classes attended a workshop chaired by Pierre Aldebert, chemist at the National Center of Scientific Research in Grenoble. Work was focused on water molecule secrets. For this second edition of the Science Week, education and culture were present at the French Institute of Meknès!

Training for a trans-disciplinary approach

Workshop chairman: David Jasmin
La main à la pâte, France
Reporter: Fenita Dyckerhoff
Sciencelab, Germany

Work was done through testimonies.

First of all, David Jasmin explained the *La main à la pâte* Eratosthenes Project and its extension to different science topics. The project invites children from different parts of the world to take measurements of shadows on the 21st of June. The measurements are posted on internet and then compared in order to measure the circumference of the earth.

In such a project, very different topics are being addressed: history, mathematics, geometry, seasons, astronomy and technology (through the use of internet).

Judit Nagy from Hungary presented the project "Save a stream", in which children collect data on a given stream and analyze them. Through their activities, the children are working on subjects such as biology, mathematics, chemistry, physics, etc.

Using the examples shown, the discussion went about trying to determine when and under which circumstances a trans-disciplinary approach is desirable and possible:

- An interdisciplinary approach is topic based: not all subjects offer the ramifications required for real trans-disciplinary teaching
- Interdisciplinary work should be linked to hands-on work
- A focus on process (as opposed to content) facilities interdisciplinary work
- Teachers should be made conscious of interdisciplinary approaches so they can move science topics to other subjects
- Teachers should be trained by people in many fields so they have a wide scope while teaching
- There is a natural link between language and mathematics that should be stressed during training

Recommendations

A generalized fact in the participating countries is that teachers are responsible for teaching all subjects. This should be seen as an asset and reinforce interdisciplinary training approaches.

Network for the Rivers "Adopt a Stream!"

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The basis for the following method was developed by the River Watch Network in Vermont, USA and adapted by the Göncöl Foundation to create the program "Network for the rivers – adopt a stream!" (NR). In this program, actors work together in order to protect the Gombás Stream.

The NR is an adapted version of the English method for kindergarten and primary schools. The subject is proposed in different modules and can therefore be easily transmitted to teachers.

The objective is to combine sensory tests and chemical and biological analyses. It must be pointed out that the order of experiences is fundamental because biological issues can modify the results of the other experiences.

Before starting with the tests it is important to select sampling points to determine the physical characteristics of the water at each point and where pollution is traceable.

It is necessary to sample two different points in order to compare the results: one sampling point upriver and a second downriver of a pollution source. The "habitat date sheet" can be filled by *sensory tests,* with a first check-up of stream surroundings making them familiar to the participants.

The sensory tests include questions referring to:

- The environment of the stream: what does the environment look like?
- To what extent is the vegetation open along the bank with respect to water oxygen levels: how much forest (100% open) or field (0% open) exists?
- The plants on the bank
- The character of the foam on the water
- The color and smell of the water
- The substrates of the river, by determining the nature of the river bottom
- The algae on the rocks
- The ragged leaves on the rocks
- The speed of the stream's current

The sensory tests are then followed by some *chemical analyses* measuring dissolved oxygen- pH-, nitrite- nitrate-levels and the hardness of the water with quick tests.

To complete the chemical description, we use some biological observations as defining the water quality by presence or absence of benthic macro-invertebrate indicators (organisms that can be seen by naked eye) which are very sensitive species for pollution and can be found next to falls and rollways, where the level of dissolved oxygen is highest.

The Trent biotic index is simple and fast and specially made for streaming waters to quantify the water quality. Furthermore, the animals chosen are easy to relate to, the index does not consider quantitative features, and it differentiates 11 groups of water quality.

The Trent index is used to follow how organisms react to organic and communal pollution. Organic pollution reduces biodiversity, hence sensitive groups gradually disappear.

The aim of the NR is the protection and recreation of water habitats through community development, educational training and corporate activities.

Everyone can join the movement because the examinations are simple and easy to learn. Consequently this method should be introduced into education systems in general.

To train the trans-disciplinarily approach

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Absent speaker

We believe that children, from the time they are born and probably even before being born, learn through an informal but continuous interaction with the environment in which they live. However, on entering school, instead of developing this ability in a structured way, they often lose this innate ability. That is the reason why practical work in science learning from the early school days onward is considered to be of the utmost importance, as long as it is done in context and with an interdisciplinary approach which takes the reality each child lives in into consideration. At this level (elementary education), neither sophisticated resources nor formal environments are needed (life is the real laboratory). The pedagogical attitude is the factor that will have consequences for children as regards the development of abilities that will be essential later in their lives. When learning conditions become more and more formal and demanding, doing science involves the elaboration of concepts about the world. However, this only happens if one is somehow familiar with the world through: observing it, developing a proper language to describe it, finding out what others have already learnt about it, testing and discussing ideas, etc.

Children must be offered diversified, systematic and contextualized opportunities to explore the world, to observe phenomena, and to test and discuss concepts. This is the natural way to learn science: it is something that students do, not something that is done for them. The project-based approach aims to encourage the participation of the child in open-ended activities with personal and social interest, involving him/her in solving problems or reaching a goal. The learning experiences take place in meaningful contexts and have an immediate usefulness. This presentation reports professional activity gained when coordinating science projects in an elementary school. This project began with my professional task of integrating children with special needs into regular classes.

The methodology used involved the implementation of small interdisciplinary projects with their origins either in everyday problems inside the school community or in topics suggested by other entities or institutions. The focus is on the acquisition of science through thought and action, the interdisciplinary approach to knowledge, and the increment of the communication within the class and between the class and the educational environment and the community.

By doing this, we were aiming, on the one hand, at creating opportunities for carrying out practical activities that allowed the improvement of knowledge and skills that are not usually valued in school and, on the other hand, we were trying to introduce new strategies into the pedagogical practice that allowed differentiated teaching strategies which met the needs of the target group.

This experience allowed us to refine collaborative work strategies with teachers working in the regular educational system. The learning that came out of this experience, though informal, was nevertheless important and has resulted in some success stories and in personal fulfillment for both the teachers and students involved.

Tutoring devices: coaching and training follow-up

Plenary conferences 3

Chairman: Sven-Olof Holmgren
The Royal Swedish Academy of Sciences, Sweden

The role of the scientific community in teachers training

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(Extract from slide's presentation)

The scientific (and technological) community: who?

1. Researchers (academic or not), engineers, with first-hand experience of active (creative) science (or technology).
2. Agreeing on the unsatisfactory status of elementary science education: content, methods, teacher training …
3. Convinced of their responsibility to improve the schools (beyond museums or other informal education).
4. Ready to give collaboration & time to this action.
5. Organized at various levels: academies of science, research institutions (e.g. ESA, CERN…), universities and engineering schools.
6. Conscious that the role of science in society is being questioned.

Possible roles of the scientific community

1. To explain and illustrate "What is science"?

   Teachers often do not have a clear idea of the very nature of science. Scientists can help to improve this, with simple examples.

   - We question nature and (sometimes) nature answers;
   - Science deals (also) with everyday phenomena of life, not only with very complicated theories or instruments!
   - The cycle *Observation/Question/Hypothesis/Experiment/Model* is for everybody, and can be applied to any situation.
   - What is a proof in natural sciences?

     The path of proof in science: an example, from simple to complex:
     - Earth is immobile
     - How do I know I move?
     - Dropping a ball from the mast of the ship in motion: what happens?
     - The principle of inertia
     - The Foucault pendulum

     or this other sequence:
     - Earth is immobile
     - Planets trajectories are complicated around Earth

    - The Sun is at the center, orbits become simple
    - Mars follows an ellipse, with the Sun at one focus
    - Gravitation determines planets motion
    - Aberrations of stars "prove" Earth's motion
    - Masses curve space-time
  - Levels of understanding are multiple;
  - Science has an history (*Europe des découvertes*) ;
  - Access to scientific knowledge (e.g. *Graines de science* in France) is worth the effort: use of *common language.*
2. To design and give legitimacy to new training methods
  - Science in vocational schools (pre-service):
    - Implement investigation methods in training;
    - Develop transverse topics (language, history..) and show how important they are for a proper investigation in science, no matter how elementary;
  - Science in in-service training: confront teacher's reactions to what they encounter coming from the children.
3. To contribute to resources for the teacher
  - Consulting services (via Internet);
  - "Coaching" of teachers (cf. *French charter*);
  - Development of material kits.
4. To foster a better understanding of "What is learning"
  - Explain the basic structures in our brain (senses, memory, emotions, thought...) and their (epi-)genesis;
  - How children get to know/understand the world around them;

   What do we know of the learning process? (Cognitive sciences)
  - The construction of abstraction: literacy, numbers…
  - The diversity of intelligence among children

The role of a science organisation in teacher training

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The fact that many pupils are not motivated to undertake studies in science and technology is widely recognized and most countries fear a lack of engineers, scientists or teachers in scientific disciplines in the years to come.

As a science and technology organization, we are well aware of that problem, even if we do not fear for our own recruitment, being rather small and attractive. But as an organization distributing more than 90% of its budget to companies and laboratories, and working with hundreds of scientific laboratories, we cannot be indifferent to that problem. In addition, the 'space' sector in which we work is one of the most motivating ones for the youth. As a starting point also, 'education' is mentioned in the ESA convention, signed by all Member States, as being one of its mandatory activities.

Since the beginning, training periods or projects have been proposed to students to help them prepare their future work in the best possible way, but this does not really change the motivation of pupils in the formal primary and secondary school system.

This is why we are developing activities aimed at supporting teachers, teachers' organizations and ministries, based on real space projects, which combine the reality of science and technology with motivating multi-disciplinary themes. We do not seek to change the curricula (even though we are ready to discuss with the people in charge), but to provide new ways and tools to teach all the teachers who are interested. These activities or tools can be exercises in support of formal courses and schoolbooks, 'space' explanations linked to the curricula, or websites that can be used by different disciplines and exhaustively present a topic.

We have now a wide range of such tools, available for free to teachers. We know that they are useful because we work with teachers (as we are not, in general, professional educators), and we get very enthusiastic comments from users. We now need to concentrate on the way we inform and train the teachers on these tools. We are aware that many teachers are not at ease with science and technology, especially at the primary level, and that even science teachers do not have all the information they would need in order to make the best use of our tools. This is why we are trying to find the most efficient ways to support teacher training so that they gain confidence in these subjects and find ideas for the classroom.

In order to allow for a wide dissemination, the teacher trainers will play an important role, not only for dissemination but also for advising us on how best to proceed. Among the projects we have started is found, for instance, a web (and/

or CD) show of tools, with selected exercises which guide the teachers through the various capabilities. This is something that could be used by trainers during information/training courses without the need to have somebody from ESA present, as this is rarely possible.

Developing primary science in-service courses at Science Learning Centre: East Midlands

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The Regional Science Learning Centre: East Midlands is one of 9 centers offering in-service training to teachers in England. It opened in October 2004. This talk will focus on its primary provision. Primary Science is a required part of the English National Curriculum. Pupils are given approximately 2-3 hours of science teaching a week. It is often taught in a very didactic way with the oldest children spending long periods revising for national tests. Our research with 2000 pupils from City of Leicester shows that pupils, and girls in particular, become significantly less enthusiastic about science as they reach 10 and 11 years old. They seem to find science is too easy and not intellectually stimulating.

Government inspectors particularly want schools to develop primary pupils' independence in carrying out investigations for themselves. However, many teachers do not do this because they lack scientific knowledge to cope with the questions pupils raise. In addition, city schools often have large numbers of potentially disruptive children and limited equipment, making teachers cautious about providing very practical activities.

A 2-year in-service program carried out in the City of Leicester showed that it is possible to improve teachers' and pupils' attitudes to science and knowledge. However, there were great differences between teachers. Four types of teachers were identified: disaffected teachers, teachers with limited cognitive development, enthusiastically fired professionals, and unaffected professionals. Each type had a different effect on their pupils. For example, pupils' attitudes dropped in classes of 'disaffected' teachers. Other pupils made gains from a low base in classes of teachers who originally struggled with science knowledge. Enthusiastically fired teachers started with average or above baseline cognitive scores and showed increases in all affective scores. However, their pupils showed little change. This may have been because the general level of teaching was good before the in-service. Unaffected professionals also started with high cognitive levels which improved slightly. Their pupils showed little attitudinal change but showed a significant cognitive gain.

This evidence indicates a 'one course fits all' approach is unlikely to be as effective or as economic as focused, differentiated courses. Some teachers need short courses to reinvigorate their enthusiasm and extend their science teaching. Others need substantial supported help. The new Regional Science Centre is attempting to provide courses that reflect what we have learnt through this research. However, despite a substantial reduction in fees, teachers choose one-day courses and do not opt for 5 –7 day courses. Our challenge is to provide what research indicates is effective CPD to teachers with limited funds and time, who are not aware of the value of sustained in-service. Consequently we are developing Mix and Match courses where teachers can attend one or more sessions, adding extra days as they start to recognize their need. We are also developing bespoke courses designed with and for individual primary schools or clusters of schools.

Tutoring devices: coaching and training follow-up

Workshop 3

Issues:

Provide recommendations about the role of resource personnel (scientists, mentors, museum resource managers, city representatives….). What are appropriate modalities for follow-up training sessions, final issues of trainings, long term repercussions? Who will ensure the follow-up, when…?

Strategic development

Workshop Chairman: Kerstin Reimstad
NTA & Linköping University, Sweden
Reporter: Pierre Kemmers
University of Amsterdam - Amstel Institute, Netherlands

The workshop topic was introduced by Kerstin Reimstad from the NTA program (working both nationwide and at Linköping municipality). She explained that NTA offers school/teacher support at three levels.

- a research and development team at national level (more in presentation by Sven-Olof Holmgren)
- a NTA coordinator for material support and training at municipality level
- a contact person at school level

She explained the central role of the teacher with respect to all the forms of support: relations with local industries; cooperation with other municipalities, other teachers, the NTA units, local universities; evaluation, assessment, professional development; material support and website.

Pierre Léna wondered whether teachers who are participating in NTA do so on a voluntary basis, and if their in-service support is accounted for in their work description or if they do it in their free time. Teachers do this voluntarily and they have allocated training time.

Thereafter, Sven-Olof Holmgren gave a presentation about the role of the Royal Swedish Academy of Sciences in the program. The Swedish Academy has a long history of stressing the importance of good primary science education. After having come across the STC program of the American NSRC, the Academy, together with the city of Linköping, set tested parts of the STC program. Due to good results and enthusiasm, the Academy asked for funding for a project to disseminate the program to other municipalities in Sweden. This project (which ended in 2003) was very successful so, afterwards, a strategy was set out for sustainable organization of the project. It was decided to decentralize the organization to the municipality level.

Currently the project is awaiting an important decision by a state agency concerning substantial funding of the current set-up.

Sven-Olof also stressed the importance of research to support a project like this. With research, the project keeps evolving and this satisfies the funding bodies. Recently, a PhD student joined the NTA program.

In a short discussion afterwards, emphasis was placed on the strategic planning required when a program makes the transition from experimental/pilot project phase to sustainable program. In Sweden, municipalities have bundled their expertise and power and are, to a great extent, autonomous but the development of the program is still governed at a national level. Research is very important when trying to convince funding bodies.

After this, the participants were sent out in 3 groups with the task of working out a strategic outline for the support of teachers. Recapitalizing, people were very enthused about this exercise as the ‘international cooperation’ worked as an eye-opener and highlighted new directions.

One group had set up several ways of improving the teacher’s pedagogical skills. They came up with courses in communication, confidence training, training in cooperative learning, etc. They also stressed the importance of improving the attitudes of participating teachers about science, for example by doing inquiries together with other colleagues. Teachers who are doing a good job should be rewarded, as this motivates them!

They have to know why they are doing science, before they learn how to do it.

Another group stressed the importance of cooperation between schools and the parental home. With special courses or support for parents, the atmosphere for children to work on science in their own time will improve, which is very important.

The third group discussed the fact that public opinion regarding the importance of good science education is also essential. No matter the level at which a country organizes its education, people have to realize that the nation’s kids benefit from good, activating science education. Only if politicians, teachers, parents, educators, inspectors, teacher trainers, and children see what good science education can do, will projects like *La main à la pâte* or NTA succeed. A project needs a certain critical mass before this can be achieved. If parents hear from friends that their kids are having a good time in school with science, parental peer pressure will drive these parents to their schools / politicians / inspectors to ask why their children are not getting science like this. Mouth-to-mouth propagation or the use of the (mass) media will spread the interest in primary science education.

Scientific implication

Workshop chairman: Pasquale Nardone
Université Libre de Bruxelles, Belgique
Reporter: Isabelle Duvaux-Béchon
ESA, France

The discussion centered on providing support to teachers in the classroom.

A first round table identified the main questions/concerns of the participants and these were developed further:

- The primary teacher might worry about calling/talking to a scientist due a perception that they exist on different 'levels'
- What quantity/quality of questions should be asked?
- What type of support can scientists give to teachers?
- How can scientists be involved in the classroom?
- How can links between scientists and teachers be strengthened?
- What is the role of scientists or the scientific community vis-à-vis educational institutions?
- Why should one thing be taught and not something else? How can one make the right choice (for the scientist when he/she is involved)?
- The relation between a primary teacher and a university teacher, for example, depends on how they position themselves (it was mentioned at that point that relations between university and secondary teachers may often be bad due to a perceived imbalance in levels of knowledge)
- The teacher might be a scientist
- The university teacher might be viewed as being too 'high up' to be interested

A testimony from Alberto Ferro (Portugal) introduced the project "Let's play with materials", which was proposed by a university teacher (engineering) who developed a series of activities for the classroom, trained the teachers to use them and accompanied them when necessary. This exists as a rather personal initiative and it seems rather difficult to bring it to a national level. As was mentioned later, the role of a strong Academy of Science is important since it can be decisive in spreading initiatives across a whole country, as in Sweden or in France.

These initiatives have to be a success as if you fail once vis-à-vis the educational system, you cannot try again.

The involvement of the scientific community (at large: scientists, organizations, students) has to be, and should be seen as being, important, and as valorizing the work of primary teachers. Doing science should raise their status in the non-educational world.

It is, however, clear that the teacher must remain the master of the classroom. The scientist and the teacher have to work as a team: the scientist does not come because the teacher does not know, but as a complement. Each one has their own skills: the pedagogical content and mastering of the classroom for the teacher and the scientific dimension for the scientist. The scientist has to have a minimum of knowledge about the functioning of the school to better help the teacher. It should be mentioned that many scientists are interested in school work, but teachers have to know them and, especially, what they can propose. A change of mentality with respect to collaboration has been noticed in many countries but it requires a long time and a lot of effort for it to be implemented.

It was mentioned that, in some cases, the initiative can come from parents, either because they ask to participate or because they try to persuade the school to evolve and change.

A concern was raised about the way in which children are evaluated at primary school, as there are countries where an examination at national level and/or a selection for secondary school already exists: we have to ensure that inquiry-based methods are not to the detriment of the way in which children are evaluated.

An interesting example has been reported from France where college students or engineering students participate in primary school classrooms to assist with the carrying out of hands-on activities. In some cases, college students obtain university credits. It seems to be a unique example, at least among the countries represented at the workshop:

Action features are:

- College students volunteering (from 3rd year of higher education)
- Discussion and definition of common conceptual objectives
- Weekly participation with the class during almost the whole school year; the college student supports the teacher and guides the children in their answers.
- Feedback provided to the teacher
- Common planning of forthcoming sessions

The student can bring material in some cases or come with a scientist for discussion on a given topic. Because of his/her young age, there is a better identification with pupils and he/she is not seen as being part of a pyramid of knowledge with the scientist at the top.

Within the frame of his/her regular curriculum, the student is evaluated by the university teacher (marks validating unit credits), although this could also occur as an initiative of students' associations.

A pilot project exists to train these students on processes, the curriculum and their role.

As there are many universities in the territory, this would promote good networking to support schools when the project extends, even if all areas cannot be covered easily.

For a teacher starting hands-on inquiry-based experimentation, there are a certain number of steps that have to be followed and questions that have first to be answered:

- What do I teach when I do experiments in the classroom?
- What is the concept?
- What are the possible misconceptions?
- How should it be taught?
- How should questions be answered and how does one find the answers? (Is it really a question or should it be worded differently?)

Teacher and scientist (or the organization supporting) should do this work together. The teacher should not forget that the experiment shows the process rather than giving the answer.

The inquiry-based approach also opens the mind of the teacher and gives both the teacher and the pupils the ability to accept that one does not know everything and that others know different things.

Collaboration can be also instilled on the production of resources as scientist or students cannot be everywhere.

Concerning the problem of answering questions, via the Internet, coming from experimentation, the example of "*La main à la pâte*" is interesting. They have approached it with the help of mediators, putting the questions in shape for scientists and "translating" the answer from the scientist before they send it back to the teacher. These mediators have both a scientific background and know educational issues.

The mediator:

- checks that the question is linked to a scientific issue
- defines a precise question if needed (interfacing with the teacher)
- sends it to the relevant scientist or group of scientists
- gets the answers and "translates" it if necessary
- sends it back to the teacher
- keeps in touch with the teacher to see how the answer was used

The "translation" is important since often the scientific language is not understandable by school teachers. This is one of the main fears teachers have when they have no scientific background. Thus the mediator is of help.

Let's play with materials
Vamos brincar aos materiais

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The project "Vamos Brincar aos Materiais", "Let's play with materials", hereafter called VBM, was launched in 1997/98 within the framework of the Portuguese Ciência Viva Program, started by the Ministry of Science and Technology for the promotion of experimental teaching of sciences in the classroom.

Initially, 10 primary schools, thirty teachers and six hundred students were involved. Today the project embraces, albeit with different degrees of involvement, sixty primary schools, two hundred and eighty teachers, six monitors and about six thousand students. One of the key issues for the success of the project is the training and coaching of teachers and monitors and the creation of a network of support and trust.

The VBM project sets up a learning platform in the classroom where the child plays the central role. Technology and materials science, physics and chemistry are the core subjects of the proposals. This core creates opportunities for multiple learning about other sciences, subjects and developments. The VBM proposes to set up a platform to Learn, a platform for Citizenship, in the classroom.

The teacher is invited to lead the class – generally five groups of five children – through a diversified, long, experimental activity carried out by autonomous students. The activity includes reading, bibliographic research, registration, technology constructions, calculus, discussion and confrontation.

The development of scientific and technological knowledge is a main objective of the project and is the natural result of the activities carried out. The proposed methodology links experimental learning and theoretical learning. However, the main proposed goal is the achievement of a change in attitude, a new way of looking the outside world and life itself. The scientific experimental research activities developed by the student in the classroom aim to induce in the child the capacity to question what he/she sees, to set up strategies to overcome the questions he/she raises, and to use proper methods to research and act. The acquisition for life of a tool, a method and a thinking strategy typical of experimental scientific research is a fundamental value-added in the development of child-student citizenship.

The primary school teachers are the key elements in the success of the activities. Their training is, therefore, a major task for the VBM project. Knowledge of the addressed subjects, readiness and self-confidence when using the proposed laboratory and technology hardware, and the ability to develop experimental research in the classroom is the standard teacher's platform. It is fundamental to allow a full development in the classroom of the potentialities of the VBM project. Teacher training resources are scarce and this poses a challenge to those involved in teacher training.

In VBM, training started in 1998. Since then around 480 teachers have undertaken our training classes and group work. The VBM standard training course class enrolls twenty teachers. The 25 hour courses are organized in ten 2h30m sections. In each course, six or seven activities are proposed, studied and worked. At present, teacher training courses are organized on a geographical basis and take place in primary schools. Classes are formed with teachers coming from schools belonging to the same group of schools, the *Agrupamento,* or from nearby schools. In a typical class the teachers are invited to act as students. Groups of five teachers are formed and the work is developed in a classroom environment using the same laboratory and technology hardware available in the students' classroom. All the accumulated experience and enrichment of the project development is brought to the teacher training classroom.

Besides these courses, school group sections are carried out to discuss ongoing activities and support newcomer teachers. The training program also embraces the task of identifying and coaching teachers to promote the development of VBM and its classroom approach in each primary school. The role of the VBM coordinator is an absolutely key element for success.

To support the activity in the classroom, particularly for new teachers, a network of professional monitors has been developed. In the VBM case, the first volunteer-based monitor network did not achieve the intended goals. From 2001, a professional network was considered the best approach for the monitor scheme. Monitors are recruited from different profiles, young primary teachers being the preferred option.

Challenges in training and coaching for action in the classroom are a key issue in the success of changing teachers and student attitudes and practices.

Pedagogical coaching

Workshop Chairman: Miquel Angel Alabart
PAU education, Spain
Reporter: Fenita Dickerhoff
ScienceLab, Germany

Miquel Angel Alabart gave a short introduction of Paueducation, a private company doing education projects for both public and private institutions (www.paueducation.com).

After making the differentiation between transferring knowledge, tutoring and coaching, based on Baumgartner, "The Zen Art of Teaching" [1] (2004) was discussed.

Once the group agreed on what coaching meant, three cases were presented to be studied by three different groups, in order to determine how a good coach advises a teacher.

The fruits of the case discussion is an attempt to define the qualities of a good coach:

- Be open
- Have previous experience in the classroom and handling materials
- Be able to listen to what teachers already know (using the same student-centered instruction used with the children)
- Coaching has to be learned, especially communication and listening skills; these do not come along with a good teacher.
- Have the ability to read people's fears and anxieties and address them directly
- Not be judgmental, be flexible and tolerant

"A good no-hands-on teacher can be better than a bad hands-on teacher. It is, therefore, important to be open and tolerant at the beginning of the process" (Yves Quéré)

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Pedagogical coaching

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Definition

- Pedagogical coaching is a modality of in-service teacher training centered on teachers' individual and collective practices.
- Objectives of pedagogical coaching are the development of teachers' own resources and skills so they learn how to solve real problems.

Pedagogical coaching and inquiry approach science teaching

- The inquiry approach requires practice-centered training methods. Initial training based on class simulations has been shown as the best way to train teachers in inquiry, hands-on-based approaches. But even then, once they return to the classroom, many teachers feel insecure and go back to old habits.
- Pedagogical coaching helps teachers to self-evaluate and improve teaching "in progress", and makes them feel secure with new ways of teaching.

Intervention in schools

- Pedagogical coaching is a modality that provides answers to the school's needs. The intervention must be contextualized and readjusted constantly to respond to the real demands and needs of every teacher. Participants must, therefore, be coached in small groups or even individually.
- Participants must have asked for pedagogical coaching or, at least, in-service training or advice. Coaching should not be an obligatory activity for teachers.

Demands and needs

- Demands must be concrete, related to problem solving, dissatisfaction with an aspect of teaching, or implementation of new methods.
- Teachers introducing new methods need to: introduce real changes in their way of teaching and cope with the emotional aspects of the new situation.
- Usually the demand is not very clear and has to do more with emotional needs (dissatisfaction, insecurity) or concrete class problems. One of the coaching objectives is the clarification of the real needs.
- Emotional and cognitive factors are involved in the changes. Several therapy methods can be used to work with beliefs, behaviors and emotions.

Sessions and results

- Sessions should include work with real practice examples. Class videotape recordings, questionnaires and observations are ideal techniques to raise awareness and experiment with new behaviors.
- A possible sequence of sessions could be:

1. Orientation phase.
2. Clarification phase. Simple behavior modification.

3-4. Modification of definitions and experimentation with changes

5. Concluding phase

- Desirable changes which pedagogical coaching causes include: awareness, change in teachers' behavior, more satisfaction with work.

Trainer

- The functions undertaken by the trainer in pedagogical coaching are related to cooperation and support, rather than to teaching or help.
- Trainers must be: teachers with experience in inquiry approach who have already been trained through similar methods (coaching, personal advice) and who have some psychological work resources.

Evaluation and research: process evaluation, neuroscience and education

Plenary conferences 4

Chairman: Pasquale Nardone
Free University of Brussels, Belgium

Assessment for learning: putting it into practice

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(Extract from presentation slides)

Formative assessment

- This classroom assessment focuses on the learning as it is taking place and its function is to bring about improvement
- Both teachers and learners need to be involved but ultimately it is the learner who has to take action

A ___________________The Gap ____________________B
Pupils Understanding at the outset — Aim for the learning

Evidence: Identify the gap i.e. A&B

Action: Close the gap
The teacher can help but the learning has to be done BY the pupil
It cannot be done FOR the pupil

Conclusion:
If formative assessment is to be effective,
the learning must involve self assessment by the pupil

Making classroom assessment work

- The content and pace of the work is determined by the evidence
- Learning is dependent on the interaction between the teacher and the learner
- Creating an environment where errors are made explicit and accepted as a necessary part in moving towards understanding

Classroom assessment

Four aspects

- Quality of questions
- Quality of feedback
- Sharing criteria with learners
- Self assessment

Messages from research studies:

- Feedback is advice for improvement
- It should be focused on the work
- It is more important that we get this right for low-ability students but it helps all learners

Erice 2005
Plenary session 4
July 13

Impact of informal science laboratories on primary science education in Germany

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Informal science laboratories, in which children and young adults can experience hands-on science activities, have been founded all over Germany by companies, research institutes, universities, and science museums. These science laboratories were founded as a response to the declining number of students electing to study the “hard” sciences such as chemistry, physics and mathematics and the below-average performance of German school children in international comparative studies, such as PISA, TIMSS, and Eurobarometer. The aim of these laboratories is to increase children’s interest in science by providing hands-on activities which allow them to experience authentic scientific endeavor and by giving a realistic and modern view of science through contact with students and researchers at their work place. Parallel to these efforts, legislation in different parts of Germany has changed the science curriculum, particularly at the primary level. In Berlin and Brandenburg, for example, science has been introduced into the primary school curriculum as a new subject to be taught 4 hours a week. Proper teacher training and equipment is, however, lacking.

Research on the impact of informal science laboratories has just begun, but the first studies indicate that these science laboratories can indeed cause an increase in the interest in science (Engeln & Euler, 2004, Physik Journal 3; Brandt, Möller, Kohse-Höinghaus, unpublished). The majority of children visiting the laboratories generally enjoyed their visit; in particular they enjoyed doing hands-on experiments, being challenged, the authenticity, and the work within teams. About 50% of the children not only enjoy but also value the visit and more than 30% would like to learn more about the subject area which was presented. The positive influence of such a visit is not short term but can still be measured after 3 months.

Like the children, teachers evaluate the visit positively. They observe an increase of interest in the classroom, especially in children who normally under-perform. Most of them would like to be able to teach science subjects in their classroom but are intimidated to teach science (Brandt, Möller, Kohse-Höinghaus, unpublished), since most of them never studied a science subject. These teachers would be able to teach science after proper training and if provided with good teaching materials. Due to this need, especially among primary teachers, to be trained in science and the experience informal science laboratories have in teaching science, a number of laboratories are offering teacher training. In addition, more and more informal science laboratories are involved in training student teachers, thus influencing future teachers. Thus the effort of scientists in informal science laboratories in Germany is starting to show positive influence on school students, teachers and student teachers.

New concepts in neuroeducation

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Education is about culture, and culture is embodied in the individual. Neuroeducation deals with the embodiments of culture in our brains during the entire life-span of a person. Neuroeducation is a trans-disciplinary field, with many actors and institutions involved. The diversity of approaches, techniques and programs reveals a bright and large spectrum of interests that should be preserved and enhanced.

Neuroeducation spans the whole variety of learning skills. The case of language is paradigmatic: cochlear implants for deaf children have changed the life of thousands; dyslexia is now treated using our knowledge of the brain processes for decoding phonemes, syllables and words. A remarkable result has been shown, recently, among senile patients that can re-activate their prefrontal cortex after some training with simple computations. In some extreme cases, as in hemispherectomized children, we can study new ways of learning with half a brain (1). But it would be wrong to limit neuroeducation to the study of brain pathologies only (I call this restriction the "neurologist bias"). The study of bilingualism, for instance, is a clear case where neuroeducation could help to establish new patterns of education for a second language We can also explore the normal development of number in the brains of very young children up to the computing skills of some prodigies. Many other skills of the arts and sciences are now explored with the new tools of neuroeducation.

The fundamental concept of "neuroplasticity" was transferred from basic research in the laboratory with cellular and animal models to clinical research and now to the larger field of education. Stanislas Dehaene (2) states that "our human ability to learn cultural objects relies on a cultural 'neuronal recycling' process whereby those novel objects invade cortical territories initially devoted to distinct but close functions". The unique *educability* of the human brain is supported by this remarkable brain plasticity. A considerable amount of work has shown the different metabolic paths and structural changes in synapses during learning, the rehabilitation of extended areas of the brain after injury, and the amazing potentiality of many neural networks to transform the processing of information and to adapt to new circumstances. Neuroeducation is always in need of good information and communication technologies. In fact, the new "digital skills" are playing an increasing role in neuroeducation and they are based in the very basic unit of the "click option" which can be identified in specific areas of the brain.

Neuroeducation is changing dramatically because some new brain imaging technologies are becoming portable, non-invasive and accessible to teachers in the classroom, the way computers have been introduced in schools and homes some two decades ago. In fact several initiatives are unfolding around the world to bridge the gap between the most advanced neurocognitive sciences and the theory and practice of education in local contexts. In Argentina, for example, we have organized a NeuroLab in a school, the first of its kind in South America, where we are studying the impact of sleep/awake cycles in learning and health, a discipline we call *chronoeducation*. We are also strongly supporting the organization of ethical committees in schools to deal with experiments with human subjects (teachers and students) in schools. This is one of the aims of *neuroethics*.

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Learning by doing and learning science

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Since the 1980's, hands-on inquiry-based learning in science has gradually been established as core curriculum in primary schools in many developed countries. In recent years, this advanced important method of instruction in science education has also expanded to some developing countries like China, Mexico and Malaysia etc. In China we call it "Learning by Doing" (LBD).

One of the important issues in development IBSE (Inquiry-Based Science Education) is assessment. How we should implement assessment on IBSE depends on what we expect from it. Three major aims have been proposed in the Chinese National Standard of Science Education for grades 3-6 in primary schools. That is:

1. Knowledge
2. Inquiry skills
3. Attitudes or performance.

For knowledge – or, more precisely, concepts and the connection between concepts – could be assessed by formative assessment and summative assessment. For inquiry skills we may use formative assessment. The difficultly lies with attitude assessment.

For a long time, cognitive science was concerned only with knowledge acquisition and neglected the emotion development of children. From the progress in neuroscience obtained in recent years, we already know that emotion, like cognition, is an inseparable important part of our mind. It influences the process of cognition, decision-making, health, creativity, violence, behavior, etc.

Comparing the aim of improving attitudes which we expect from IBSE with emotional competency we find that they are very close to each other.

From the view of Learning Science (Neuro-Education), we know that emotion affects the process of learning, from attention to retrieving. Through IBSE we can better cultivate children's emotion competency, particularly for those students who have difficulty in learning. It is stronger evidence of the advantages of the learning methodology of IBSE.

Some primary studies using psychology methods to compare the emotion competency of children have been undertaken in Shantou University. The studies show improvements in children's emotion competency following IBSE.

Now we are developing instruments to record the emotions some children express, including recording facial expressions, gestures, voice and some physiology signals, in order to monitor the changing of emotion. We hope it can be used in evaluating the process of children's learning.

Research and resources for science education in Italy

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Absent speaker

National and international surveys continually highlight the problem of the inadequate school performances of Italian students in scientific and technological matters. The increase in science teaching, starting from primary school, is felt in Italy to be a very important task and it is the object of a very large debate.

Curriculum Standards for infant schools (since 1991) and elementary schools (since 1985), tied to the reform delineated by law n. 53/2003, clearly fix the role of the basic school in contributing to the development of student's observation and logical-linguistic skills. However, in practice, these indications are not followed.

Key aspects of the problem are:

- The inadequate initial training of teachers: until now, the majority of Italian primary and infant school teachers were not graduates. They received non-specialist training for science, only a generic and almost pedagogic training in high school. Since 2000, new primary and infant school teachers have required a 4-year graduated initial training: "Scienze della formazione primaria".
- The scarcity of teaching supports for helping them in their job (opportunities to obtain information and training, materials, research results dissemination);
- The scarcity or lack of instruments (apart from books).

In order to respond to these issues, plans have been implemented by research agencies, public organizations, and teachers' associations. In 1999, the Education Ministry (MPI, now MIUR) proposed a 4-year special plan for scientific and technological education (Plan SeT), involving around 500 schools, connected to the Internet, all over the country.

Within this scope, it is interesting to analyze the Montessori model. It uses concrete materials to illustrate the origin and formation of the Earth (laboratory experiments in chemistry and physics), the study of geology and physical geography. The goal is to have a permanent scope, enlarging the child's ideas and allowing him/her to understand synthesis. Physics is presented to the child so that he/she may extend his/her understanding beyond the world of the senses. Children might estimate the width of the universe by means of the imagination. To satisfy the natural interests of children they are introduced to the plants' and animals' environment by emphasizing their interdependence. The child who is aware of the system of interdependence (ecology) and who actually explores and observes Nature will find the techniques of classification to be valuable aids to his understanding. The biological sciences, however, are not taught simply for their own sake but with the intention of giving the child a sense of respect for the life around him/her, so that child may be capable of assuming a collaborative rather than a destructive ecological role. This kind of education starts at the age of 3 in the child's house and continues in the primary school. It is based on the fact that teachers are specifically prepared for this kind of education.

Evaluation and research: process evaluation, neuroscience and education

Workshop 4

Formative evaluation

Workshop chairwoman: Christine Harrison
College London/University of London
Reporter: John Clark
Deakin University, Australia

The transition from teaching dominated by summative assessment to a pattern of formative assessment where students become self-monitoring learners raised a number of issues which were discussed during this workshop.

When a teacher learns formative assessment, a number of changes occur in the questioning techniques. The teacher is seen to be:

- Using a problem as a stimulus for question rather than asking lower order (simple) questions;
- Increasing wait time after questions;
- Focusing on problems rather than responses; and
- Increasing the amount and quality of dialogue between pupils.

This dialogue between pupils is seen as changing from a conversation like table tennis to a conversation like volley-ball – so that conversation go bouncing between pupils with the teacher stepping back and ensuring that the ball is kept in play. Rather than the simple question-response-teacher statement pattern of traditional classrooms where the teacher dominates talk (twelve times as much talk as students), the conversation can soar, moving quickly or slowly for sustained rallies.

When primary teachers ask students to generate questions, a common concern is that they will not be able to answer students' questions because of their lack of content knowledge. A number of solutions were proposed. It is not necessary for teachers to feel that they must answer all questions. Changing the response from 'I don't know' to 'We don't know' removes a lot of pressure from teachers. Questions can be sidestepped by putting the question in a question box or on a question tree and telling students that we will ask a scientist. A number of internet services are provided for this purpose as well as visits by scientists to the classroom. Another method of reducing the pressure that the teacher feels is the categorization of questions that students ask into questions that:

- don't need to be answered
- can't be answered
- we need to answer
- are not important but which can be answered

The shift from summative to formative assessment needs:

- seeing that teachers can do it, either by observing the successes of other teachers or one's own success in the classroom;
- the confidence to take risks; and

- teachers to think on a meta level analysis: getting teachers to think about the purpose of the assessment, and the purpose of the questions they are asking their pupils.

When teachers change their assessment practice it can produce opposition from parents, educational administrators, department heads, and even other teachers. The education of parents is important as they may be disturbed if they see fewer grades and work as continuously changing drafts rather than beautiful finished products. This can be done by setting up exhibitions illustrating the process of learning and by getting students to present to parents their learning rather than a product. Other teachers and departmental heads can be influenced by the effect on the pupils.

Three lessons were learnt:

- that teacher training takes time;
- that we need to find the pupils' voice about their learning; and
- that teachers need to think about the types of feedback that help student learning.

Education and neuroscience

Workshop chairmen: Wei Yu
Research Center for Learning Science
Southeast University Nanjing, China

Antonio Battro
Neurolab – MarinCollege, Argentina

Reporter: Pierre Kemmers
University of Amsterdam -Amstel Institute
Netherlands

At the Institute of Education Development in Belgrade, research has been conducted on the teaching and learning activities of young people (See abstract p.72). This research is based on the viewpoint that children are curious and interested in activities related to discovering physical phenomena. The aim of the research was to find out how such activities could be improved and developed.

The teaching and learning activities presented were based on results obtained after several years of study of children's comprehension of physical phenomena, as well as on experience in selecting contents for experiments and their adjustment to preschool and elementary school children. The selected materials were enriched by contact with children. Their questions and answers stimulated the research team to improve the design of the experiments. One of the important findings of the research is that the "excitement and fun of finding answers through science processes should be the means of how to teach science".

A long discussion after this talk converged on the boundary of learning theories and teaching/pedagogy theories. How can each inform the other?

According to Antonio Battro, the focus in neuroscience is on how learning can be understood on a brain/neuron level. This is similar to cognitive or developmental psychology as it was practiced by influential people such as Jean Piaget and Lev Vygotsky. They focused their work on how children *learn*. However, Piaget was only interested in the spontaneous development of intellectual capacities. He never took the social environment of the learner into account, let alone its influence. In this respect, Vygotsky gives us a more valuable insight into learning in a social context with his social development theory. In neuroscience, the effect of teaching on how a child learns is taken into account more and more. Most animals are able to learn in some way, but it is unique to humans that we can influence other people's learning by teaching/pedagogy. It is important to note that education is the combination of learning *and* teaching.

Sven-Olof Holmgren remarked that in the process of maturation a child learns individually to cope quite well with its world. It learns, for example, to speak and walk. In formal schooling, the child is taught such things as reading, writing, and counting, which are non-intuitive subjects.

However, the problem with science is that children learn to cope with their physical world by themselves. This is what science is about as well. The problem is that science is often contra-intuitive: one can form satisfactory ideas about the physical world that are not in line with the ideas that scientists hold. We speak of naïve conceptions.

Normal teaching methods are not adequate to solve these naïve conceptions that the child holds. This speaks in favor of hands-on methods in which the in-built ideas of children are challenged by “real evidence”.

It would be interesting to see how theories of learning and teaching can inform each other. In this workshop it has become clear that insights into how children learn can inform teaching on an individual level. However, in a formal schooling setting it is more common to have 25 children to one teacher alongside other constraints. To include these two in a theory of education is no common practice.

Children's comprehension of physical phenomena
at preschool and lower elementary school level

Vera Bojović
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My contribution deals with research on teaching and learning activities for young children, based on the viewpoint that children are curious and interested in activities related to discovering physical phenomena. The aim of the research was to find out how such activities could be improved and developed.

The teaching and learning activities presented in my contribution are based on results obtained after several years of studying children's comprehension of physical phenomena as well as on experience in selecting contents for experiments and their adjustment to preschool and elementary school children. The selected materials were enriched by contact with children. Their questions and answers stimulated us to improve the design of the experiments.

Various physical phenomena were selected for teaching through discovery. This approach to the subject can be called "discovery teaching/learning". Attention was paid, on the one hand, to the presentation of every experiment, keeping in mind the complexity of the phenomenon and, on the other, to the children's ability to understand them.

We shall offer experiments adapted to children's mental and physical stage of development. These experiments make it possible for children to become acquainted with physical phenomena in an active way.

We also took various other requirements into account, such as simplicity of equipment and materials for experiments, simplicity of procedures, entertainment and variety, possibility of independent work, safety of the children, etc.

Unobtrusive help and stimulation from the teacher during experiments – without depriving children of the joy of discovery – has great importance in developing the initial motivation of the child and his/her interest in natural sciences.

We hope our research and a series of experiments we offer contributes to finding ways of how to meet this demand.

General conclusions

Pierre Léna, Académie des sciences, France

During the last decade, inquiry based science education in primary schools has been the focus of considerable international interest in the scientific and pedagogical communities. The *InterAcademy Panel* – the worldwide federation of science Academies – co-chaired by our friend Yves Quéré, has set up a special program (chaired by Jorge Allende, from Chile) to deal with science education according to the principles of inquiry. In many countries new ideas, innovative experiments, and new curricula have recently emerged and these have led to remarkable realizations.

Curiously Europe as a whole seemed to be absent from the scene despite a number of national projects and initiatives. With the Lisbon objectives in mind – developing education to build a society of knowledge by 2010 – this situation seemed quite unsatisfactory. This is the reason why a number of early European actors decided to propose to the European Commission the *Scienceduc* action, finally funded at a very modest level, which has gathered us in the beautiful town of Erice during this summer week of 2005. Here *Scienceduc* emerges from e Mails and paperwork to become a reality of exchanges and discussions, new ideas and challenges. Fortunately the attendance has extended beyond the five member countries of the *Scienceduc* project but has been much broader, with eighteen nationalities represented from Europe and beyond. We have shared our common interests, solutions, and hopes in a surprising convergence, all the while keeping in mind the young children we work for, their curiosity and their future in this new century full of promises and risks.

Teacher training has been at the heart of our discussions as the teacher's ability and preparation for inquiry pedagogy is the most strategic issue of all. We have heard a number of perspectives on this from Estonia, France, Germany, Hungary, Portugal, United Kingdom, Sweden, United States, as well as discovered research programs in Argentina and China.

We have questioned the *methods* of this training and converged on the need for time, continuity of effort, and the necessary partnership between education authorities and institutions.

We have underlined the *role of scientists* to establish adequate training places, for example *science labs* in Germany, the *science centers* in the UK, and the *centres pilotes* in France. The presence of many active scientists in schools is a clear demonstration of this involvement.

We all agree that *evaluation* is a key point for future developments. This includes three aspects: evaluation of students, evaluation of teachers, and evaluation of systemic approaches. The United Kingdom, Sweden and China have all proposed interesting paths to explore.

Let us now attempt to be more specific on some of our tentative conclusions.

1. What is Inquiry pedagogy? We have identified many problems in order to reach a consensual set of definitions – possibly no more than a one-page summary – at least within the *Scienceduc* project. We have addressed the issue of the disciplines and the possible roles that different disciplines could play. Physics offers (apparently) simpler situations, easier variables discrimination and quantitative experiments. It also creates more fear among teachers than biology. Biology is indeed more complex. Experiments in biology may be more difficult or impossible and models are often necessary but paradoxically teachers (and perhaps children) often prefer it. Chemistry is difficult without calling upon microscopic models, which are often beyond the understanding of primary school students. Astronomy, although limited to observation and models, seems to receive an easy and positive consensus. Technology was not deeply discussed, although it is clearly part of the landscape. We should remember to be tolerant and open, an excellent *vertical* science lesson being preferable to a poor inquiry *horizontal* lesson.

2. Polyvalent teachers: We have all insisted on the virtues of polyvalence in primary education. It allows an easy link between learning in the (natural) sciences and other disciplines, such as mathematics, language, history or geography. We have heard many good examples of the use of polyvalence, e.g. in Hungary (*Save a stream*) and in European Space Agency projects. The multidisciplinary approach avoids putting science in *boxes*, forces a focus on process rather than on content, and recognizes complexity. However, it requires a wide variety of scientists for coaching and designing the projects.

3. What should a training session be? Many possible formats were discussed, but there was a clear consensus on the need to have teachers themselves practicing inquiry (hence, the need for a proper definition of inquiry). They are pressed to ask their questions, to open their mind, to dare expressing their a priori ideas on the scientific topic being discussed, and to produce a personal experience of truth. Teachers have to clearly visualize what they do and what they intend to do: What do I teach? Which concept (more or less abstract) do I try to have the students elaborate? Which are my misconceptions? and which results did I achieve during this sequence? Changes in curriculum may be good moments for teachers to re-evaluate their role and knowledge. Exchanges among teachers are extremely valuable and should be encouraged. Several initiatives were cited such as La main à la pâte (www.lamap.fr) and international collaborative projects between classes. Given the size of the primary school system and the huge number of teachers, amplification mechanisms – if possible non-linear – have to be designed to realize training at a large scale. Should one emphasize pre-service or in-service training?

4. What is the role of scientists? This role was emphasized by many speakers. A long report has been produced on the subject with many new ideas. The scientists valorize the teacher's efforts, they help them to manage the classroom, they can be mediators and translators of science in order to make it understandable, and they can be consulted via the internet (as in France). Coaching of teachers is not entirely trivial. It has to be learned. It requires flexibility and tolerance. It takes time to implement but is extremely fruitful. If advanced science students coach teachers, it could be counted as credits in their curriculum.

5. Strategic development: Experimental inquiry development on a small scale is interesting and leads to helpful prototypes but is not sufficient if a systemic change is desired. Sweden has provided a remarkable model of systematic implementation on a reasonably large scale, with a highly structured program, including: strong support by the Academy and scientists; negotiation with municipalities; and teacher training (as yet only voluntary). Many issues are important for a sustainable model of implementation, including money and resources. The importance of evaluation and research findings supporting the value of inquiry pedagogy has been stressed as a key ingredient to convince political authorities and obtain wide-scale support. Nevertheless this remark, often made, has not yet led to concrete proposals for real action. Also the role of parents, media, and public opinion in favour of inquiry-based teaching is important.
6. Formative evaluation: It is necessary to help the teachers to evaluate their practice and its *technical* aspects (for example the *art of questioning* children). They have to learn to categorize the children's questions, to reduce the psychological load on themselves, and to accept the *I don't know* and not feel destabilized. The suggestive image of a volleyball game (between children and teacher) was suggested as being more adequate than the image of a ping-pong game. Formative evaluation should be connected with the coaching of teachers (by scientists and trainers), measuring their progress, and building confidence. An interesting idea was suggested: to record systematically exchanges in a classroom and research on the progress of questioning, and the teacher's attitudes and answers.
7. Neuroeducation: This is an entirely new and fascinating field, which is currently expanding. It was remarked that research is at the moment focused on the processes of learning, but not at all on the process of teaching. Where do the two processes meet and how? One can learn without being taught (e.g. by imitation). So what does the teaching add, and how? The discussions were challenging for many of us, and we listened carefully to the questions and methods from China. The school *Mind, brain and education* held in following week in Erice, with some of us attending, brought new insights on the matter.

Looking to the future after this excellent start of *Scienceduc*, we observe that this project is a very modest one, by comparison with the immense task of renovating elementary science education in Europe. It is formally limited to 5 countries, with the possibility to begin working with Germany and Italy. We shall publish the proceedings of this summer school, and then hold the seven national seminars, with – whenever possible – some cross-participation within the network, in order to enhance the perception of a European approach to the subject. There is also the forthcoming IAP Stockholm Conference next September, which will organize an international, long-term program on evaluation of inquiry-based science education.

As this summary is written some time after the conclusion of the School the pessimistic view then presented, namely the failure of the *POLLEN* proposal made to the EU, can fortunately be revised. *POLLEN*, with 12 countries and a significant budget, was finally accepted during the summer of 2005, and should begin on January 1, 2006. It will possibly lead to an even more ambitious proposal that is to be submitted to the EU by the end of January 2006. Success in scientific research in Europe has been achieved thanks to a convergence of scientists' high-level objectives and solid base-level research which has convinced governments to fund major scientific projects, for example CERN, ESA, and ESO. There is no reason that education goals should be any less successful, as they can be rooted in the European traditions of excellence (Comenius, Erasmus and so many others) and benefit from the rich diversity represented in Erice.

The School would have never happened and been so successful, without the committed involvement of Pamela Lucas and David Jasmin, who have been the real *Directors* of this week. I am sure all of us applaud them for their dedication, as we applaud all the speakers, reporters and chairs of workshops. Finally, I would like to extend our grateful thanks to Antonino Zichichi : without his generous support and trust, the school would not have existed; and to Fiorella Ruggiu, who has been so helpful at all the critical moments, and to her staff.

Good wind to *Scienceduc*, *POLLEN,* and the children we all work for!

An IAP statement on science education of children

Mexico City, 04 December 2003

Must all children learn science at school?

The answer is "yes". Science opens young people's minds to the wonders of the natural world, introduces them to the elegance and honesty of the scientific endeavor, and equips them with cognitive and problem-solving tools that will serve them well in the future.

Science brings children closer to the natural objects and phenomena that surround them, endows them with a rich understanding of our complex world, helps them practice an intelligent approach to dealing with their environment, and teaches them about the techniques and tools that societies have used to improve the human condition. As *children* become familiar with the universality of the laws of science, they also learn to recognize science's ability "to create and cement together a unity for humanity" (A. Sakharov, *Science et Liberté*, Éditions de Physique, 1990). As *citizens*, science helps children develop the mental and moral predispositions to imagination, humility, rigour, curiosity, freedom and tolerance - all essential ingredients for peace and democracy.

Therefore, the *InterAcademy Panel* (*IAP*) recommends to all leaders of nations that:

1/. the teaching of the sciences to both girls and boys begin in their primary and nursery schools. There is evidence that children, from the youngest age, are capable of building upon their natural and insatiable curiosity to develop logical and rational thought;

2/. this teaching should be closely tied to the realities with which the children are confronted locally, in their natural environment and their culture, in order to facilitate continuing exchange with their family and friends ;

3/. this teaching should be based, to a large extent, upon models of inquiry-based pedagogy, assigning a major role to *questioning* by the students, leading them to develop *hypotheses* relating to the initial questions and, when possible, encouraging *experimentation* that, while simple in terms of the apparatus used, can be performed by children themselves ;

4/. in this manner one should avoid, as far as possible, a teaching of the sciences which is handed down *vertically* by a teacher enunciating facts to be learnt by heart, in favor of one which is transformed for children into an acquisition of knowledge which is *horizontal,* that is, which connects them with nature – inert or living – directly, at the same time involving their senses and their intelligence;

5/. links should be established between the teachers, via the Internet, first within their own country, then internationally, taking advantage of the universal nature of the laws of science to establish a direct contact between classes in different countries on subjects of global interest (e.g., climates, ecology, geography) ;

6/. priority should be given everywhere to the networking of schools, and that support should be given – in the same way as the IAP and ICSU work on this jointly via the website www.icsu.org/8_teachscience/icsu-iap/ to efforts to develop shareable experiments and teaching tools (such as documents and experiment portfolios) to be placed in an electronic commons for all to modify and use.

We, the undersigned science academies throughout the world, members of the IAP, are convinced that, with the support of international authorities, the backing of the national ministries concerned, and the dedicated efforts of the many scientists whom they bring together, a worldwide effort in this area is within arm's reach. This effort is potentially rich in major intellectual and societal benefits.

Signed by 68 academies of science, worldwide.

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International School of Science Teaching

European Summer School for Primary science trainers

Erice, Italy : 9 – 14 July 2005

PROGRAM

SATURDAY, JULY 9

Arrival day – registration

Participants must arrive in Erice on July 9, no later than 5 p.m.

SUNDAY, JULY 10:

The inquiry-based method at school:
Process steps, teacher's role, process elements common to European teachers

Plenary session 1 / Chairman: Yves Quéré – Académie des Sciences, France

9h00 – 9h45:

What is our feeling about science? (Overview and objectives of the Summer School)
Yves Quére, Académie des sciences, France

9h45 - 10h00:

Scienceduc: *european renovation of science teaching with inquiry methods*
Pamela LUCAS, *La main à la pâte*, France

10h00 - 11h00:

The Role of Literacy in Student Scientific Reasoning
Karen Worth, Education Development Center, USA

11h00: Coffee break

11h30-12h15:

Learning science in Elementary school
Margarida Afonso, Centre of Educational Research, University of Lisbon, Portugal

Workshop 1

Issues:

List draw up of common elements defining inquiry-based science teaching (Principles, process characterization, how to introduce the process into the class?) Specificities for life science teaching, for physics and technology teaching, and for kindergarten teaching

Workshops modality: classroom simulation

16h00 - 18h45: Parallel Sessions:

Session 1.1: *Teaching Process for Life science (except pre-school)*
Workshop conductors: Peter Rockel and Fenita Dyckerhoff - Science-Lab, Germany

Session 1.2: *Teaching Inquiry-Based Physics in the Primary School*
Workshop conductor: Tina Jarvis - Science Learning Centre East Midlands, UK

Session 1.3: *Science teaching process for pre-school*
Workshop conductor: Karen Worth - Education Development Center, USA

19h00 – 19h30: Report elaboration
Only for workshop conductors, reporters and summer school director

MONDAY, JULY 11

Teacher training on inquiry-based method: Introduction and requirements for process implementation

Plenary session 2 / Chairwoman: Karen Worth - Education Development Center, USA

9h30 – 11h50: Round table

9h30 - 9h40:
Round table introduction by the chairwoman

9h40 – 10h00:
Teacher training in France
David Jasmin, La main à la pâte, France

10h00 – 10h20:
The Swedish model for in-service training
Kerstin Reimstad, NTA/ RSAS, Sweden

10h20 – 10h40:
Teacher training on the inquiry-based method
Toomas Tenno and Karin Hellat , Tartu University, Estonia

10h50 – 11h50: Discussions

Workshop 2

Issues:

Define the elements required to implement training sessions in European countries for an inquiry-based process in science: Are classroom simulations required? What are their limits? How should one proceed? Should one move from process to contents or from contents to process? Training approaches: scientific and pedagogical content.

Workshop modality: testimonies and discussion

16h00 - 18h45: Parallel Sessions:

Session 2.1: *Training process*
Workshop conductor: Karen Worth - Education Development Center, USA

16h00 - 16h10:
Introduction by workshop conductor

16h10 – 16h30: Testimony
Scientific Education by immersion
Sophie Hulo – Université de Genève, Switzerland

16h30 - 16h50: Testimony
Teaching primary science to pre-service primary education students within primary schools
John Cripps - Deakin University, Australia

16h50 - 18h45: Discussion

Session 2.2: *Resources for trainers*
Workshop conductor: Nicolas Poussielgue –Ministry of Education – Senegal

16h00 - 16h10: Introduction by workshop conductor

16h10-16h30: Testimony
Resources for pre-service training
Nicolas Poussielgue –Ministry of Education – Senegal

16h30 – 16h50: Testimony
“Stories of water: dirty water, clean water, drinking water”
Evelyne Touchard, Ministry of Education, Grenoble Academic Inspection, France

16h50 - 18h45: Discussion

Session 2.3: *Training for the trans-disciplinarily approach (science and language, science and history…)*
Workshop conductor: David Jasmin– La main à la pâte, France

16h00 - 16h10: Introduction by workshop conductor

16h10 – 16h30: Testimony
"Network for the Rivers: Adopt a stream!"
Judit Nagy – Göncöl Foundation, Hungary

16h30 - 18h45: Discussion

19h00 – 19h30: Report elaboration
Only for workshop conductors, reporters and summer school director

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TUESDAY, JULY 12
Tutoring devices: Coaching and training Follow-up

Plenary session 3 / Chairman: Sven-Olof Holmgren - Royal Swedish Academy of Sciences (RSAS), Sweden

9h00 - 9h45:
Role of academics/scientific community in teacher training
Pierre Léna - Académie des sciences, France

9h45 - 10h30:
The role of a science organization in teacher training
Isabelle Duvaux-Bechon – European Space Agency, France

10h30: Coffee break

11h00-11h45:
Developing Primary Science In-Service Courses at Science Learning Centre: East Midlands
Tina Jarvis - Science Learning Centre East Midlands, Leicester, UK.

Workshop 3
Issues:

Provide recommendations about the role of resource personnel (scientists, mentors, museum resources, city representatives). Appropriate modalities for follow-up training sessions, final issues of training, long term repercussions. Who will ensure the follow-up, when…?

Workshop modality: testimonies and discussion

16h00 - 18h45: Parallel Sessions

Session 3.1: *Strategic development*
Workshop conductor: Kerstin Reimstad – NTA, Sweden

16h00 - 16h10: Introduction by workshop conductor

16h10 – 16h30: Testimony
Strategic development under the academy perspective
Sven-Olof Holmgren –Royal Swedish Academy of Sciences (RSAS), Sweden

16h30 - 18h45: Discussion

Session 3.2: *Scientific implication*
Workshop conductor: Pasquale Nardone - Université Libre de Bruxelles, Belgique

16h00 - 16h10: Introduction by workshop conductor

16h10 - 16h30: Testimony
Let's play with materials
Alberto Cabral Ferro – Instituto Superior Técnico, Portugal

16h30 - 18h45: Discussion

Session 3.3: *Pedagogical coaching*
Workshop conductor: Miquel Angel Alabart - Paueducation, Spain

16h00 - 16h10: Introduction by workshop conductor

16h10 - 18h45: Discussion

19h00 – 19h30: Report elaboration
Only for workshop conductors, reporters and summer school director

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WEDNESDAY, JULY 13
Evaluation and research: process evaluation, Neuroscience and education

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Plenary session 4 / Chairman: Pasquale Nardone, Université Libre de Bruxelles, Belgique

9h00-9h45:
Assessment for Learning: Putting it into Practice
Christine Harrisson, University of London, UK

9h45-10h30
Impact of informal science laboratories on primary science education in Germany
Petra Skiebe, Germany

10h30-11h15:
Neuroeducation
Antonio Battro, Academia Nacional de Educación, Argentina

11h15: Coffee break

11h45-12h15
Inspire from Learning Science
Wei Yu, CAST- South East Nanjing University

Workshop 4

Issues:

Understanding the evaluation process, tools and establishing links between research and classes

Workshop modality: Testimonies and discussion

16h00 - 18h00: Parallel Sessions:

Session 4.1: *Formative evaluation*
Workshop conductors: Christine Harrisson University of London, UK

16h00 - 16h10: Introduction by workshop conductor

16h10 - 18h00: Discussion

Session 4.2: *Education and Neuroscience*
Workshop conductors: Wei Yu and Antonio Battro

16h00 - 16h10: Introduction by workshop conductors

16h10 – 16h30: Testimony
Learning by Doing and Learning Science
Wei Yu – CAST- South East Nanjing University

16h30 – 16h50: Testimony
Children's comprehension of physical phenomena at preschool and lower elementary school level
Vera Bojovic – Ministry of Education and Sports, Serbia and Montenegro

16h50 - 18h00 : Discussion

18h15 – 18h45: Report elaboration
Only for workshop conductors, reporters and summer school director

19H00-19h30: General report

THURSDAY, JULY 14
Departure day

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