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Bridging the Gap between Formal Education and Informal Learning via Science Centre Pedagogy

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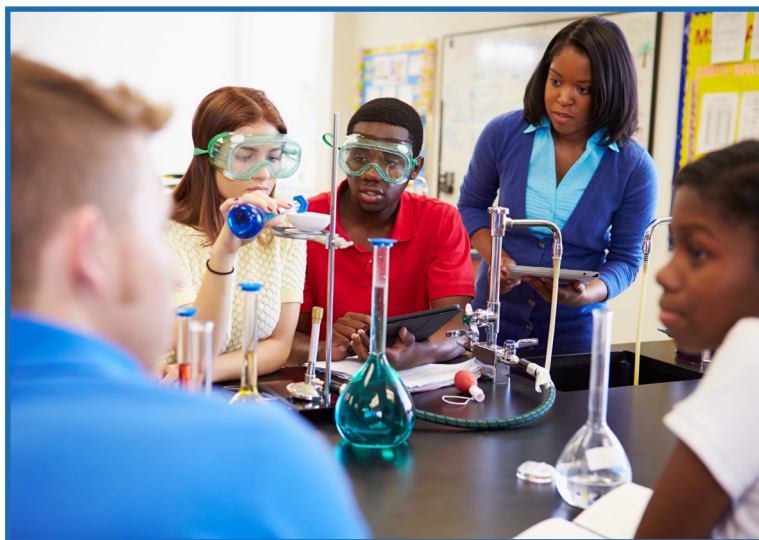
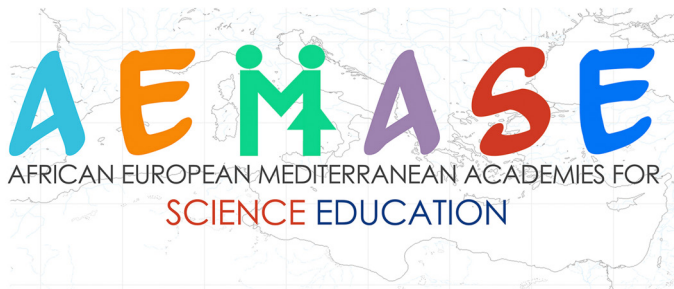
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INTERNATIONAL AEMASE CONFERENCE ON SCIENCE EDUCATION

Conference Report

prepared by



ACCADEMIA NAZIONALE DEI LINCEI

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Academies



International AEMASE Conference
on Science Education
Conference Report

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Accademia Nazionale dei Lincei

All European Academies (ALLEA)

This document details the proceedings of the
INTERNATIONAL AEMASE CONFERENCE ON SCIENCE EDUCATION
Rome, 19 - 20 May 2014.

Chair of the Conference:

Lamberto Maffei, President of the Accademia Nazionale dei Lincei, Italy

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Mostapha Bousmina, Académie Hassan II des sciences et techniques, Morocco
Hoda Elmikaty, Bibliotheca Alexandrina, Egypt
Odile Macchi, Académie des sciences de l'Institut de France
Giancarlo Vecchio, Accademia Nazionale dei Lincei, Italy
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Conference website: www.lincci.it/convegni/AEMASE

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Foreword

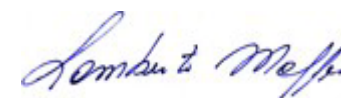
This two-day conference concentrated on science education, a priority in today's society. We seek to improve science education at the elementary school level. We want to provide resources and training to science teachers and enhance student learning through an inquiry-based approach. Providing an adequate science education to the very young means providing an education that teaches children to reason, to reason logically, and grow up to become active rather than passive citizens. To summarise its importance in a few short words, science education is a positive step to ensure democracy and freedom.

The *Accademia Nazionale dei Lincei* is very active in science education programmes, particularly in primary and secondary schools, in many parts of Italy. With the support of our Academy Fellows, mathematics and experimental science are taught using the Inquiry-Based Science Education approach. These programmes have been very successful and far exceeded our expectations. We hope this conference will help bring the hands-on approach towards studying science to schools all over the world.

I am honoured to have chaired this International Conference on Science Education, which has brought together participants from more than 30 countries across five continents. I would like to express my deepest gratitude to the Conference Organising Committee, particularly the

Co-Chairs, Odile Macchi and Giancarlo Vecchio. They were the mind and motor behind this conference and without their continued efforts and enthusiasm this conference would not have been possible. I also wish to thank our Academy's Foreign Relations Office for the tremendous amount of work and skill which went into the international organisation of this meeting.

I would like to conclude by thanking most warmly all of the participants for coming to this important event. Your expertise, knowledge and ideas were and still are very valuable and needed. Lastly, I wish all the readers of this report a fruitful and informative reading experience.



Professor Lamberto Maffei

President, *Accademia Nazionale dei Lincei*

Rome, 19 May 2014



Conference Participants at the *Accademia Nazionale dei Lincei*
Photo courtesy of Professor Benő Csapó

Preface

In our respective capacities as President of NASAC, the Network of African Academies of Sciences and President of ALLEA, the European Federation of Academies of Sciences and Humanities, it is our pleasure to preface this first AEMASE Conference Report with a few brief remarks.

We would first like to express our warm thanks to the members of the Organising Committee, who were instrumental in preparing this meeting on the wonderful premises of the world's oldest Academy of Sciences, the *Accademia Nazionale dei Lincei*. When we look at the impressive list of institutions and associations involved in organising and supporting this Conference, as well as AEMASE's Mediterranean regional focus, it is clear that the *Accademia* was the perfect venue for this first meeting, since this Academy takes a very active part in many of the manifold efforts and engagements of the different networks which have assembled at this Conference.

In Science Education you have two words: Science and Education. If among the objectives of science is to understand nature and to interact with it for the well-being of the humankind, the objective of this meeting was rather related to the methods and approaches of science. This is because science has its own language, its own methods and approaches that are very rigorous and precise and to the best of our knowledge there is no other political, ideological, theological or any kind

of message that could be equivalent to or stronger than the message of science. Why is that? Because rigorously speaking, science is in its essence rational, its concepts are general, and it is impartial. It does not depend on any external influence, such as religion, politics, ideology or superstition. It depends neither on the person who is dealing with the scientific matter nor on his or her origin, color or gender.

The second term in Science Education is Education. Of course, among the objectives of education is to train alumni and students to acquire certain knowledge and teach them how to use such knowledge in their future career. But beyond this technical training, the most important objective of education is to help achieve a better society with citizens who are respectful to humankind as well as nature. To reach such a goal, one has to acquire scientific methods that are based on fundamental pillars such rationality, scepticism and a critical attitude towards any message could it be narrative or explanatory. And when such rationality is absent, you see radical behaviours, such as the recent events in Nigeria, with Buku Haran. Those people who kidnapped the girls in Nigeria do strongly believe that they did so rightly, because rationality was absent in their education. Their minds were infected because they did not acquire the necessary knowledge and tools to be protected against external influences. As a less violent example,

many people around the world refuse to take medicines of any kind due to their non-rational beliefs.

These are two among many examples of why science education is so valuable for societies. But it is crucial for governments to understand this importance, too. In Europe, for example, the European Commission is working to build a European Research Area (ERA) to promote Europe-wide research and innovation. But one pre-condition to the construction of the ERA has not been properly dealt with: how can we build a European Research Area if we do not, at the same time, think of a European education area? An education area in which we try to offer the best possible opportunities for children and young people to be educated and trained according to their individual potential and needs. Our responsibility is to offer fora and possibilities where we show our young people how exciting it is to acquire new knowledge, to apply new knowledge and to communicate about new knowledge.

This is of course not only true for the European continent. If Europe and Africa intensify their cooperation in the field of research, it is paramount that we develop a joint strategy to support the education of our young people, especially in those fields such as mathematics, informatics, natural sciences and engineering, which are particularly critical for increasing the innovation potential of many societies.

Because curiosity and scientific interest are already present during the first years of childhood, the issue is not to instill these elements in young people, but rather to maintain and preserve them.

The inclusiveness of this conference enabled a joint dialogue and invited us to take a look beyond our own spheres, revealing different views and perspectives. Working together offers great opportunities for synergies and added value, and it is useful for avoiding the duplication of efforts. We hope that this meeting can help establish contacts that will become opportunities for international twinings and collaborations, so that the resources and expertise in Science Education can be exchanged in a concrete and reciprocally beneficial way.



Professor Mostapha Bousmina
President of NASAC



Professor Günter Stock
President of ALLEA

Conference Background and Objectives

The AEMASE Conference is an initiative of several academies and institutions aimed at promoting science education and science outreach to society in a geographically North-South region centred on the Mediterranean Sea. This region shares strong and ancient scientific and political links. The event was organised by the *Académie Hassan II des Sciences et Techniques* of Morocco, the *Accademia Nazionale dei Lincei* of Italy, the *Académie Nationale des Sciences et Techniques du Sénégal*, the *Académie des Sciences de l'Institut de France*, and the *Bibliotheca Alexandrina* in Egypt. The Conference was made possible through the generous support of IAP, the global network of science academies; the *Compagnia di San Paolo*; All European Academies; and both the *Accademia Nazionale dei Lincei* and the *Académie des Sciences*.

In developed countries, science education is currently viewed as inadequate, with a decline of student interest in scientific careers. This risks lowering the level of industrial innovation and imperilling these countries' economic future and sustained social welfare. A sound science education system is also critical in developing countries because it efficiently speeds up development, economic growth, and the improvement of human welfare. Championing formal and informal science education and fostering the scientific literacy of citizens are thus crucial for all countries. Primary and secondary school education is particularly important, since these le-

vels involve huge numbers of pupils and most citizens receive their basic cultural education there. Thus, in many nations in this North-South region, science education is calling for attention.

In many of the countries represented at this Conference, programmes for renewing science education, based on the Inquiry-Based Science Education (IBSE) pedagogical method, have already been developed. One example is the French project *La main à la pâte* (LAMAP). Indeed, many successful programmes funded in the European Framework Programmes 6 or 7 (FP6/FP7) have put an emphasis on IBSE.

However, the current economic crisis slows down the national upscaling necessary for IBSE teacher training and professional development. This is indeed a costly and challenging task which demands strong commitment, pro-active efforts and voluntary interaction from three professional worlds: scientists, experts in the training of science teachers, and education policymakers. The presence at this Conference of many high representatives from Ministries of Education is a very encouraging fact. No matter which country or professional background, scientific or administrative, the participants of this Conference share the hope of increasing the potential to empower a partnership between the scientific world (e.g. Science Academies) on one hand and Ministries of Education on the other hand, with a

common objective of improving formal and informal science education through the implementation of IBSE in schools and promoting the professional development of teachers of science.

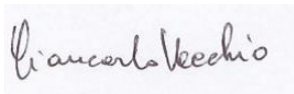
The organisers of this Conference are strongly convinced that the exchange of regional or national experiences will enrich both Northern and Southern countries: when faced with a difficult challenge, exchanging good ideas and know-how, as well as projects and experiences, is not only joyful but also fruitful. In fact, a major goal of the AEMASE Conference is to disseminate the know-how that was gained at the meeting as a place for peer-to-peer sharing of the best practices and pooling resources for teachers' professional development. Through mixing participants from the North and the South in the Conference sessions, direct interaction and proactive behaviour was highly encouraged.

Furthermore, the Conference aims to prepare and facilitate the establishment of future multilateral international partnerships and twinnings, either on IBSE projects or on informal science education. With this objective, the Conference folders included feedback forms through which each delegation could report those specific aspects of science education in another country with whom they would like to interact. This allowed the merging of participants with similar objectives and maximised the chance of potential

further collaborations. The organisers hope that contacts thus voluntarily established between countries during the Conference will eventually become twinnings and collaborations, so that the available resources and expertise in IBSE and informal science education can be exchanged in a concrete field manner. Finally, the Conference seeks to facilitate the launch of pilot projects inspired by the FP6 and FP7 European projects by supporting applications for funding by international institutions concerned with education.



Professor Odile Macchi



Professor Giancarlo Vecchio

Co-Chairs of the AEMASE Conference Organising Committee

Keynote Lecture

Science Education in Schools: A Challenge for Academies and Scientists

Professor Pierre Léna

Fondation La main à la pâte, France

Learning to read, write and count has been a challenge for basic education in many countries during the twentieth century. To face the twenty-first century problems, young people need to be able to reason properly; a new challenge that science education needs to address. The evolution of humanity on planet Earth renders the educational challenge even more pressing. No more “business as usual” when facing climate change; biodiversity threats; or huge human migrations with forced labor. The “school as usual” approach will not be sufficient to prepare youth for the complex situations which they are foreseen to address by the middle of this century. The grounds for action are twofold: sharing the role science plays in today’s culture through education and with equity on one hand, and providing the required skills and tools for development on the other. However, the challenges are severe: to begin at an early age (6–12 year olds); to teach real and interesting yet easy science; and to address all students, regardless of their future professional inclinations, whether boys or girls.

Achieving the desired goal does need a profound pedagogical revolution. This

revolution requires continuous engagement of the scientists and the engineers and requires the openness of the schools to their local environment and communities.

In the last decade, a wealth of pilot projects dealing with educational challenges have flourished. Often at a small scale, they nevertheless explored the principles of the required pedagogical revolution. Pilot projects mobilised thousands of teachers and scientists in different countries, commonly with important contributions from science academies, which are more able to address political and education authorities. In most of these cases, science academies have been either leading the change or have been at least involved, as in the recent 2012 study carried in Europe with ALLEA, or in the action of IAP worldwide with its science education programme.

A consensus was established among these projects on a need for an inquiry pedagogy. A notion that has now been analysed in depth. If so many pilot projects in such a diversity of countries can agree on this line of action, it is certainly due to the universality of science, as well as to the universality of children’s curiosity during their golden age of inquisitive minds (approximately 6–12 year olds). The challenge here is to harmoniously combine these universal factors with the precious diversity in culture, language and education systems. With overwhel-

ming evidence, the major challenge is teacher's preparation and professional development and their proper exposure to lively, authentic science and engineering in an interdisciplinary spirit. To properly develop an inquiry pedagogy, pilot projects show that primary school teachers require several years of continuous professional development, which in turn entails a significant cost.

What is the real impact of these pilot projects on development issues such as the qualifications of the work force, the role of technology in modern societies, the resilience of cultures and traditions to the uniform model of globalisation, and sustainable development? Do we have clear proof of their impact, or is it an act of faith to believe in the role of science education in helping the development of a society?

In 2015, the publication of the UN 2030 Sustainable Development Goals will show the approach that education should pursue. It will be an added challenge to the current classical inquiry approach to consider how to best utilise the new pedagogy to better understand the goals and to apply it to the youth.

After the success and the lessons of these pilot projects, time has come to consider large-scale expansion, in order to expose the tens of millions of children who deserve sound science education to the new techniques and to empower them

with the necessary tools to deal with the problems of the future. How should one proceed with this second, but extremely difficult step of the revolution? Placing teachers and scientists in organised and long-term contact is one direction, which has been successfully explored in the UK with the National Science Learning Centres since 2006, and in France with the *Maisons pour la science au service des professeurs* since 2012. In Africa, although with a different scope, the several African Institutes for Mathematical Sciences (AIMS) organise a high value transnational training for graduates. Overall, the issue remains open and will deserve vigorous effort and creativity in the coming years. The combination of teacher's distance professional development, using online and new interactive methods such as Massive Online Open Courses (MOOCs), and the necessary campus-based training in disseminated centers over large territories such as Africa or Brazil, is probably the best way to proceed but will need the local support of scientists, engineers and science/engineering students.

These measures for carrying out an effective revolution in science education will probably remain of modest impact if, in many countries, the social status and the salary of teachers in basic education are not raised.

We would like to formulate here an additional and ambitious proposal. In 1980, Pakistani physicist Abdus Salam, having

won the Nobel prize in 1979, decided to create a place where the physics students (mostly postdocs, some PhDs, and also senior scientists) coming from developing countries would have the opportunity to meet the greatest scientists of the time and to be exposed to lectures during residential retreats of reasonable duration. The Italian government had the generosity to financially support the initiative and the International Center for Theoretical Physics that was created in Trieste. For the last three decades, this Center has played a fundamental role in helping scientific research—not only physics—to begin and develop in many countries otherwise condemned to remain absent from the science scene and to see their talents brain drained by the developed ones.

The proposal is to create a similar venue today, which will be devoted to science education, where teacher's trainers and scientists of high repute and interest for inquiry development from all over the world would meet, discuss models, elaborate tools, exchange resources, and develop strategies. Above all, scientific and engineering contents and processes would be exchanged in an organised and interdisciplinary manner. Internet and distance cooperation would follow the direct exchanges, in order for each participant to benefit from a post-retreat follow-up. The Internet would indeed facilitate the work.

This proposal is based on a twenty-year experience of inquiry-based pilot projects: it is well demonstrated now that the involvement of scientists of high calibre is crucial to the pilot projects, which in turn prefigures the need for a pedagogical revolution. Would a country or an organisation consider, as a worthwhile goal, the undertaking of the establishment of such a permanent Center and allocate the adequate resources?



Participants share their experiences during one of the Conference sessions.
Photo courtesy of Professor Benő Csapó

National Projects¹

Subject-specific Continuing Professional Development (CPD): the Role of Science Learning Centres

Professor Derek Bell
College of Teachers, UK,
Member of IAP Global SEP Council

Abstract

This paper outlines the case for subject-specific CPD and describes the development in the UK of the network of Science Learning Centres. This overview highlights the key elements of the initiative, its evolution and the challenges it has had to overcome in the last 10 years.

Introduction

The discovery of new knowledge and understanding in science continues to accelerate and the social and ethical context of science is more significant than ever before. Not only is there a demand for high class scientists and engineers, but also there is an increasing requirement for individuals who may not be working in the scientific arena but, nevertheless, need the skills to contribute to a technologically advanced society. These demands place a big responsibility on science educators who in turn need to be up to date with the new developments in

science and ways of equipping students with the basic scientific knowledge for their chosen careers and future lives. Against this background, subject-specific continuing professional development (CPD) is particularly important for science teachers.

Following publication of *SET for Success* (Roberts: 2002), the UK put in place a series of measures designed to engage more young people with science, technology, engineering and mathematics (STEM). The wide range of activities aimed to inspire young people through the awe and wonder of science; the potential of technology and engineering to provide solutions to challenges facing the world today; and to improve awareness of careers available to them. Central to the initiatives was the establishment of a network of Science Learning Centres to provide high quality, subject-specific CPD for science teachers and technicians. The underlying premise being that it is the standard of teachers and the teaching they provide that is the key to high quality education for all young people.

Highly accomplished teachers who are effective require an immense range of knowledge and skills. Although some of these qualities are generic, teachers also need to have: enthusiasm for their subject, understanding of their subject, knowledge of the curriculum to be taught, and the ability to communicate their subject in a way that learners will

¹ The following section encompasses a selection of the information presented at the Conference during numerous oral presentation and poster presentation sessions attended by the participants. When possible, graphical data from the original presentations have been included.

understand. Importantly, such teachers must keep up to date with developments not only in subject content but also with the associated pedagogy. The vision for the network of Science Learning Centres was to make this possible for science teachers.

The network consists of a national centre and nine regional centres. The National Science Learning Centre, funded by the Wellcome Trust, is based at the University of York in a new specially designed building to include teaching rooms, laboratories, resource base and hotel standard accommodation for residential courses. It is run by MyScience.co Ltd. and jointly owned by the Universities of York, Leeds, Sheffield and Sheffield Hallam. It opened in 2005.

The regional centres, which were funded by the government department of education, opened in 2004. Seven were based in universities (Manchester Metropolitan, Sheffield Hallam, Keele, Leicester, Hertfordshire, Southampton, and Institute of Education London) one at Framwellgate High School Durham and one in the interactive science centre At-Bristol. The regional centres focussed on non-residential courses while the National Centre provided residential courses.

Overall, the network of science learning centres is seen as a success story. Designing, organising and delivering courses for teachers on a national scale is big

undertaking but the network has succeeded in doing so for over 20,000 teachers in both primary and secondary schools across England and, through the National Centre, in Scotland, Wales and Northern Ireland. However, there are underlying challenges that needed to be addressed in order to bring about a change in attitudes, behaviour and culture in relation to professional development:

1) Many teachers need to be convinced. In a study carried out by the Wellcome Trust (2006) it was found that 12% of teachers surveyed were dubious about the benefits of CPD which they saw as focussed on government initiatives rather than their own professional needs and 33% might agree that CPD was important in principle, but doubted its quality or relevance. The combined 55% all needed convincing that future CPD would deliver something of value.

2) Teachers and schools need funding support to cover the cost of the training and to replace the teachers while they are on their courses. This was addressed by establishing Project Enthuse, a partnership between the government, Wellcome Trust and industry partners, which provides bursaries for teachers to attend courses at the national centre. Since introducing these in 2008 over 10,000 teachers in 72% of English secondary schools have benefitted.

3) Teachers also need access to high quality teaching resources. The National STEM Resource Centre, co-located with

National Science Learning Centre, was set up in 2009 to provide easy, free of charge access to high-quality resources, information and guidance to support teachers in enhancing young people's engagement with STEM subjects. Its e-library has 8,000 assets and the physical collection is in excess of 25,000 items.

4) The model for such networks has to evolve in order to keep up with changes in the education environment. Thus in 2013 the network of science learning centres took on a new structure which had only five "regional centres" each of which has established science CPD hubs in schools operating at a much more local level. These new Science Learning Partnerships aim to increase CPD expertise more directly in schools so that programmes are more sustainable and that attitudes and behaviours are embedded in the culture of the profession more widely.

Despite the challenges, the success of the network of science learning centres is being demonstrated through its own evaluation work which shows an increasing body of evidence of the positive impact on teachers, schools and ultimately young people. For example, teachers report increased confidence, enhanced subject knowledge and career progression. Schools show increased uptake of STEM subjects post-16. Young people appear to be improving their achievements in STEM, more likely to continue their studies in STEM and have a better understand-

ing of where STEM can take you in terms of careers. These findings are backed up by national data (e.g. NAO 2010).

Without doubt much has been achieved, but there is still a long way to go. In a changing education landscape STEM must be kept high on the agenda and its role as an essential part of a balanced education must be enhanced for *all* students, not just those who will become the scientists, mathematicians, technologists and engineers of the future.

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Website links:

Science Learning Centres: <https://www.sciencelearningcentres.org.uk/>

Project Enthuse: <https://www.sciencelearningcentres.org.uk/about/partners/project-enthuse/>

National STEM Centre: <http://www.nationalstemcentre.org.uk/>



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Science in Education Projects in Albania

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In the framework of Science Education in Albania, there are involved the Ministry of Education and Sport (MoES), the Institute of Development of Education (IDE), other educational institutions, universities, research institutions and centres, academia, etc. Our partners are also parents and local businesses. Numerous projects have been carried out or are ongoing in different fields of science: as ICT, Biology, Mathematics, Physics, etc. Pre-university subject-based curricula are also being upgraded in competency-based curricula, among others.

I. Integration of the Information and Communication Technology (ICT) in the subjects of grades 1-9 of compulsory school in Albania

The results of technological developments which would have been inconceivable 20-30 years ago are today inevitable in our everyday professional and private lives. Beyond the entertaining dimension, the innovation of the ICT represents challenges for the new generations, including teachers.

The “Microsoft” is an example as to how this challenge is overcome. Unfortunately, in our schools today, the teachers’ knowledge on new technologies is still poor. Students have better skills in informatics than the majority of teachers. The introduction of new technology in schools requires broader knowledge and skills, as well as creativity by teachers.

This project focusses on the teachers’ training and their certification. We have to focus on the real needs of the job market. Therefore, the identification of the new talents in students since the secondary school and the strengthening of their skills through incentives as well as their capacity building are of paramount importance. To achieve this, creative and qualitative teachers are needed. It is not enough to discover new talents and teach students, but also to train teachers and equip them with appropriate instruments and mechanisms to increase the potential in Albania.

Science in education is the right way to respond to this situation. A national conference was held in Tirana to present the project on the “Integration of the ITC in the subjects of grades 1-9 of compulsory school”. A CD was also developed that includes new dimensions for a contemporary teaching in Primary School (grades 1-5) and model classes in Mathematics-Physics.

II. *On the safety of children using the Internet*

The use of the internet offers unlimited information. It brings knowledge, is entertaining and informative on everything happening in real time near, or far. From the other side, as with any free and powerful mechanism serving the needs and requirements of the public, we often face dark aspects, which certain individuals might use for evil-minded goals which may include harming children.

According to the World Vision investigation in Albanian schools, 85% of children have access to the internet, many PCs are in their bedrooms, 62% of interviewed children have confirmed that they have come across pornographic networks more than once, and 47% of interviewed children confirm that they have been contacted by foreigners and that this has happened more than once.

During the survey, children are able to recommend how to sensitise them to internet safety. Children have pointed out the needs for awareness campaigns, training, the use of free hours, or classes devoted to the information-awareness, specific meetings in the schools, a joint programme with twinned foreign schools, and the coordination with the local and central government for making safe browsing possible in private internet centres. The guarantee of the safe internet for children remains among the MoES priorities.

The internet navigation safety for the students and its management are part of the MoES Protocols that foresee conditions for private internet companies. In the framework of the national project “School as Community Centers – Friendly Schools for All”, the schools are expected to cooperate more closely with the community and parents, who exchange opinions on the safety issues of their children using the internet and suggest training topics, etc. The MoES in cooperation with the local universities is foreseen to organise ITC practices for students in compulsory schools, so that they can not only contribute, but also gain experience, which is useful for the job market.

Community parents with relevant ITC knowledge and skills are expected to contribute as partners in this ambitious programme. In the framework of the project: “On the safety of children using internet”, a National Conference organised by the MoES and “Microsoft”, was held in Tirana. To that purpose, the following have been realised: 1) a study on the contemporary experiences on the safety of children using internet; 2) an elaboration of literature concerning the issue; 3) the compilation of the draft-brochure “On the safety of children using internet”; 4) the preparation of the module: “On the safety measures for children using internet”; 5) the promotion of this brochure at a National Conference focussing on the topic “On the safety of children using internet”.

Besides the use of tablets in the teaching-learning process, this project also points to the need for the necessary improvements at the pre-university curricula at national scale, and the training of teachers.

III. *A school that uses tablets: The future learning of the new generation in Albania*

This project is implemented by the MoES and aims to introduce a new technology in the pre-university education in Albania. This is a new initiative for a radical change of the teaching process from the technological point of view. “InfoSoft” and “Microsoft” have donated tablets in some pilot schools. Other donors offered also their experiences in different teaching-learning fields.

The MoES will cooperate with curricula expert universities under the continuous direction of IDE that will monitor the teaching-learning efficiency after the introduction of these new IT methods. The goal is to test the introduction of this method in 110 schools initially, by facilitating the electronic communication among teachers and students, as well as the exchange of information with the community, learn from it and extend the experience later on a national scale.

IV. *The Competency-Based Curricula Reform in Albania*

The MoES and IED are working on “The Competency-Based Curricula Reform in Albania”. The science-subject-based curriculum is being reformed covering pre-school (3-6 years), primary (grades 1-5), lower secondary (grades 6-9), and upper secondary (grades 6-9).

A society that is based on knowledge and on information technology requires people with appropriate skills. In this context, the new conception of the Competency-Based Curricula must be the main focus of the education (Skilbeck, 1990).

Based on the above, the new competency-based reform aims at developing opportunities to allow interaction of students, teachers and technologies of all kinds. The school and education must be thoroughly reformed in order to permit the application of the new Competency-Based Curricula.

Surveys show the link among the motivation, attitudes and self esteem with the achievements and career choices. The motivation to learn mathematics and science is important not only from the school performance aspect, but also from the role that it has in relevant professions for the economy.

In Albania and in some other European countries, there is a concern for the low

learning achievements in mathematics and science-technology Subjects. This fact also affects the low performance of these subject teachers in the Teaching Universities. Recent policy change supported by the new “Normative Provisions” in curricula also include the “reinforcing classes” in support of the students with low learning achievements in science, mathematics, etc.

Some key reform objectives are: reformation of the “Curricula Package”; development of the pre-service teacher qualification; development of information technology and didactic material; reformation of the student assessment; transformation of the school into a democratic and community place that incites the formation of the core competencies (as interpersonal, intercultural, civic, intrapreneurship, capacity to transform the ideas into actions, inter-cultural understanding, etc.).

The whole curricula reformation process will be accomplished in close cooperation with Kosovo. A “historical agreement” between the Kosovo and Albania Ministers of Education was signed on 3 June 2014 in Tirana.

The agreement is not only about the unification of the two systems, but also for the curricula and textbooks by starting from pre-school up to high school (grade 12). The main intention is to ensure unification of the curricula framework, core

curricula, textbooks (although not identical ones), etc.

V. Other activities of the “Science Education Programme” in Albania

The Academy of Sciences has organised an Open Day on the “Science Education Programme” for the upper secondary students and the “Scientific Forum” with academicians, professors and researchers from inside and outside Albania.

The TEH Programme

Professor Jacques Blamont

Advisor to the President, Centre national d'études spatiales (CNES), France

The TEH (*Transformer l'Enseignement en Haïti*) was initiated in the wake of the January 2010 earthquake as part of the French programme of relief to help destroyed schools.

The idea was to produce modules in French, send them to Haiti by satellite links and help Haitian school teachers to assimilate the methods of presentation of the contents.

Immediately, at the first contact with Haitian teachers, it became obvious that the major problem would reside in the differences of culture and language and that we would have to invent a system of transfer of knowledge.

Our objective now is to improve the pedagogy of the teachers by introducing them to the LAMAP method. The basic fact is that at least 80% of the teachers in Haiti have received no training at all or very inadequate training.

We work only in the public education system and our trade is the teaching of fundamental concepts and methods. Following the indications of the DEF (Directorate of fundamental Teaching, Ministry of National Education and Professorial

Formation), we use as a base the network of the EFACAP (*Ecole fondamentale d'Application - Centre d'Appui Pédagogique*). Each EFACAP is surrounded by about 30 schools and provides complements to the teachers of each school through the help of 3 pedagogic counsellors (CP) per EFACAP.

In the school year 2012-2013, we operated in 11 EFACAP plus 5 schools in Port-au-Prince, with the help of 31 CP. We reached 675 teachers directly in continuous training and 33,750 students indirectly.

Our pedagogy follows as mentioned the LAMAP method, an active approach characterised by emphasis on investigation to stimulate scientific reasoning, understanding of the world and capacities of expression. The teacher proposes situations generating investigation to the students and steers their reactions towards reasoned conclusions.

We concentrate on six disciplines: experimental sciences, mathematics, French language, information and communication technologies, health, and school inclusion following the official Haitian school programme.

The resources are developed in a joint effort of French specialists collaborating with the CP in iterative loops: one loop between the French developers and the CP, followed by a loop between the CP

and the classes. Therefore, the contents (partially in Creole language) are adapted to the situation observed in the classrooms.

The training is provided at two levels:

1) To the CP: one introduction each year at the beginning of the year, given to the 33 CP by the French producers of resources. One group called iteration group is dedicated to supervising and co-producing the contents. Its members are CPs and they communicate on a weekly basis with the French module producers. We are satisfied to observe that now the members of the iterative group and other CPs have become able to produce their own modules by themselves, without French help. The construction of a library of modules is on its way.

2) To the teachers: our real target, 42 sessions of one full day are offered under the leadership of the local CPs at each of our 11 sites. During the week following each session, CPs evaluate the result in classroom, providing the second loop.

The French experts visit classes once or twice a year with CPs in order to observe the benefits to the teacher and to sharpen the training case by case.

These experts are themselves teachers or pedagogic advisors and are responsible for the conception of the contents used in the programme, in interaction with

the CPs of the iteration team. The close contact between those drafting the courses and the schoolchildren themselves through the double loop has provided satisfactory results: at the end of the school year 2012-2013, an internal evaluation has shown that our teachers had mastered 50% of the method after two years of training. These positive results have convinced our sponsor, the BID, not only to continue its support for the 2013-2014 year, but also to pledge to maintain support for the next year.

Lessons that can be drawn are:

1) The political context in Haiti is characterised by large governmental instability, with top personnel changing frequently. Haitian administrative structures lack the financial, human and material resources for fulfilling their part of the project. The Ministry of Education is in particular very short on personnel and also has trouble paying its teachers and administrators regularly. These difficulties reverberate heavily upon cooperative programmes. They should be considered a part of the project, deserving major attention and work, and not as a nuisance.

2) Financing a project such as TEH, which displays some measure of success, has no difficulty finding sponsors for money to be spent in Haiti. But financing the part spent in the donor country (France in the case of TEH) is extremely hard. Some hope is placed on European funding.

3) Training and teaching in developing countries needs mediators, or go-between people (in the case of TEH, the CPs are the mediators). Much effort has to be given to the training, satisfaction, and salary of these mediators.

4) Students have to be taught in their native language and lectures have to be prepared with the intervention of the mediators. These principles lead to the idea that the end of the chain (the children) has to be involved in the design, format and delivery of the lessons. The teachers, when foreign, have to also learn from the people they teach.

Note: The TEH programme is a joint programme between the MNEFP of Haiti on one side and the Academy of Sciences and CNES on the other side.



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The Italian National Network of Academies for Education

Professor Francesco Clementi
Accademia Nazionale dei Lincei,
University of Milan, Italy

One of the main concerns of the *Accademia Nazionale dei Lincei* is the insufficient literacy of the Italian population regarding science and language according to results from the international student and working population assessments. Science education can be achieved through both formal curricula in schools and informal events such as festivals, meetings with scientists, social networks, newspapers etc.

In Italy, several such occasions of science popularisation are organised, even at a good scientific levels, but their impact on science knowledge and appreciation is limited and short-lasting, particularly in areas in which the school curricula are not well implemented. One of the factors that may contribute to this situation is the difficulties of the Italian education system in providing an adequate scientific background and, in particular, in placing science in the context of our cultural humanistic heritage. Therefore, the *Accademia Nazionale dei Lincei*, whose mission is “to promote, coordinate, integrate and disseminate scientific knowledge in the context of the unity of culture”, decided that it was time to also take action in the field of science teaching.

The Academy is involved, at the moment, in three projects related to science education: 1) “WHAT TO KNOW? FINDING IT WITH ACCADEMIA DEI LINCEI” in collaboration with Rai Educational (the national broadcasting company) for new information at the frontiers of science, 2) “A DAY WITH THE LINCEI” in collaboration with the local Academies and Universities to stimulate high school students to pursue scientific careers at university level, and 3) the project “A NEW TEACHING FOR A NEW SCHOOL: A NATIONAL NETWORK” with the aim of offering a new approach to teaching science in schools in Italy. The project is based on simple ideas:

- i) A strong and persistent increase in science literacy and comprehension can be achieved only through a modification of science teaching in schools
- ii) To improve science education we need to change how teachers teach and to assist them in this task, thus making teachers the targets of the project
- iii) Science should be conveyed to students in a way that captures their interest, stimulates their mind and creativity and should be of high quality
- iv) Science literacy is not knowledge of more scientific facts but a passage from ignorance to understanding
- v) Science teaching should start very early in the school curriculum and continue th-

roughout schools years with a continuum development

vi) Teaching should be based on a laboratory approach, as in IBSE

vii) Science should be placed in the Italian cultural context, and delivered with an appropriate argumentative language

viii) The disciplines to focus on are Science (mainly biomedical and chemical aspects), Mathematics and advanced knowledge of Italian language (Table 1); the choice of these three disciplines have been made on the basis of several new findings coming from neuroscience and experimental psychology on learning (Heim et al, *Frontiers in Evolutionary neurosci*, 4,1,2012; Butterworth and Kovas, *Science*, 340, 300, 2013) and on the relations and convergences of learning objectives in these disciplines (Stage et al, *Science*,340, 276, 2013).

After a two-year trial in two centres (Naples and Rome), the project has been extended throughout Italy, under an official agreement with the Ministry of Education and teachers’ associations. The project is organised as a network of Centres, each one based at a local Academy of Science and Literature, which in Italy are numerous and maintain a high scientific standard, and is under the leadership of the *Accademia Nazionale dei Lincei*, which provides the general organisation and coordination and ensures the scientific validity of local programs as well as the necessary connections with other international and national initiatives with the same purposes.

This year, 12 Centres, covering nearly all the Italian regions, were active in the project (Table 2), involving 1,162 primary and secondary schools, 2,736 student-teachers and approximately 123,000 school

Mathematics	Laboratory of Mathematics, conceived not only as an equipped classroom, but also as a moment in which students learn to design and conduct experimental observations on objects, know how to interpret results, formulate simple predictions and hypotheses and logical arguments.
Natural Sciences	Extend the science teaching approach according to the Inquiry-Based Science Education (IBSE) for primary schools, associated with a modern update on the frontiers of science for secondary schools.
Italian	Familiarise students with a broadly argumentative text type (an editorial of a newspaper) or didactic-descriptive (an essay of science, history of science, sociology, etc.). Texts that are functional as a linguistic device for enabling a student to fully understand and write a text of this kind.

Table 1: Outline of the programme of the disciplines

students in 4,300 classrooms. The 257 teachers delivering the courses were university professors assisted by experienced secondary school teachers, and the hours of instruction totaled 1,870 (Table

3). The effectiveness of the methods was assessed at the end of each course. The project was welcomed with interest and enthusiasm by school teachers and administrators, and the new methods expe-

Location	Base	Coordinators
Roma	Accademia dei Lincei	Prof. Giuseppe Macino
Bari	Bari-Lecce University,	Profs. Giovanni Martelli, Ferdinando Palmieri
Bologna	Accademia delle Scienze, Golinelli Foundation	Prof. Tommaso Ruggeri, Ing. Danieli
Brescia	Catholic and Brescia Universities, Grazioli Foundation	Profs. Marco De Giovanni, Renzo Piva
Milano	Istituto Lombardo Accademia di scienze e lettere, CARIPLO Foundation	Profs. Francesco Clementi, Gianpiero Sironi
Napoli	Napoli University, Polo della Scienza, Stazione Zoologica	Prof. Giancarlo Vecchio
Perugia	POST Foundation	Prof. Giuseppe Macino, Ing. Enrico Tombsesi
Pisa	Scuola Normale di Pisa	Prof. Giuseppina Barsacchi
Torino	Accademia delle Scienze	Prof. Aldo Fasolo
Venezia	Istituto Veneto di Scienze Lettere ed Arti	Prof. Gian Antonio Danieli
Catania-Messina	Catania and Messina Universities, Verga Foundation	Prof. Gabriella Alfieri
Future Centres		
Basilicata	University of Basilicata	Profs. Francesco Vitielli, Vincenzo Schettino
Sassari	Sassari University	Prof. Piero Cappuccinelli
Reggio Calabria	University for foreigners „Dante Alighieri“	Luca Serianni

Table 2: Centre distribution in Italy

perimented on during the courses were in many instances subsequently applied in the classroom.

work in dedicated laboratories for some time; and study interdisciplinary projects focussed on the importance of language in science.

In the future, we plan to: transform this project into a more established Science Teaching Programme involving all Italian regions; enhance cooperation among teachers; increase cooperation between high level scientific institutions and schools; prepare training programmes based on laboratory methodology; increase the opportunities for teachers to

Centres	No. Prof	No. Courses	No. Hours	No. Teachers	No. Students	No. Schools	No. Classes
Roma	19	20	64	212	10600	141	192
Venezia*	15	19	58	30	1500	29	61
Milano	32	55	868	787	39350	240	645
Brescia	17	12	36	143	7150	64	280
Torino	31	30	44	58	3354	45	125
Bologna	15	6	141	428	21400	185	856
Perugia	17	4	71	120	6450	60	240
Pisa Napoli**	33	43	345	312	1425	158	624
	31	24	71	263	13150	85	526
Bari	34	17	86	193	9650	89	386
Catania	22	15	45	190	9450	72	380
TOTAL	266	245	1829	2736	123479	1162	4315

* No Mathematics | ** No Italian

Table 3: Activity of the Centres in the year 2013-14

**Minor Academy of Sciences of Ukraine:
National Experience of Science
Education Development**

Professor Stanislav Dovgyi

*President, Minor Academy of Sciences of
Ukraine*

The Minor Academy of Sciences of Ukraine (MAcS) is an extracurricular educational system that organises scientific activity for the students, creates conditions for their intellectual, spiritual, and creative development and vocational self-determination, and assists the increase of scientific potential of the country. MAcS is subordinated to the National Academy of Sciences of Ukraine and Ministry of Education and Science of Ukraine. 25,000 secondary school students are annually involved in scientific research in 12 subject areas subdivided into 61 sections and guided by 6,500 pedagogues.

The goal of the MAcS of Ukraine is to help promote intelligent, highly educated, socially active persons who represent the best achievements of national and international education, science and culture.

Tasks

- to identify, develop and support students who have aptitude to scientific activity;
- to create a favorable environment for talented children of Ukraine;

- to support professional self-determination and creative self-realisation of pupils;
- to facilitate the exchange of experience working with gifted and talented children and youth;
- to promote science education among students and teachers.

Cooperation and partnership

The creation of a platform for communication that serves as an integrated environment for the interaction of researchers, teachers, educators, government officials to unite their efforts in the formation of a young scientists pool became possible due to the building of national and international bridges. As a result, MAcS of Ukraine receives governmental support from the Ministry of Education and Science of Ukraine, the National Academy of Sciences of Ukraine, and the National Academy of Pedagogical Sciences of Ukraine. Apart from cooperation at the national level with academic institutes, educational establishments, companies and businesses, MAcS of Ukraine collaborates with international partners such as the European Organisation for Nuclear Research (CERN), the Experimental Laboratory for Young People in Goettingen (XLAB), the Argonne National Laboratory, and the Development Centre Opinkirjo, etc. MAcS is a member of the World Council for Gifted & Talented Children, the European Council for High Ability, the European Association of Institutions of Non-formal Education of Children, and

the Youth and European Association of Neuro-Oncology.

Achievements

- 250,000 children from all over Ukraine are involved with MAcS by means of participation in the scientific activity in humanities, natural and exact sciences.
- MAcS of Ukraine holds over 40 international and national mass events for children and over 30 national events for teachers annually, focussed on vocational training in multiple fields.
- Scientific research laboratories for students are created and are well equipped. They offer students a model of how to conduct personal research as well as acquire and apply skills.
- Innovative education approaches are launched: educational webinars, online consultations, online experiments, etc. In addition, the system offers each student either distant or online access to guidance from scientists for their research projects.
- MAcS of Ukraine bridges the gap between school and university education, creates a unified system of communication between schoolteachers and leading scientists, and connects students and leading scientists.
- Members of MAcS of Ukraine received over 100 patents and certificates of copyrights for their scientific innovations.
- Methodical, scientific and analytic

materials about the organisation of scientific activity for students are published.

- Members of MAcS of Ukraine participate in intellectual competitions at the national and international levels (European Union Contest for Young Scientists (EUCYS), International Conference of Young Scientists (ICYS), International contest Intel ISEF, etc.).

Experience of MAcS of Ukraine

An extensive, integrated, multilevel state system of science education within the framework of MAcS of Ukraine has been formed. It encompasses and integrates all levels of education – from preschool and general education to academic. Education based on research enables the formation of research skills that serve a lifetime.

Planetarium Science Centre: Science Clubs Initiative

Dr. Ayman Elsayed

*Deputy Director, Planetarium Science
Centre of the Bibliotheca Alexandrina,
Alexandria, Egypt*

Project description and implementation

Science Clubs Initiative (SCI) is an ambitious project of the Planetarium Science Center (PSC). It aims to introduce the principle of interactive activities in the study of science in schools so that it becomes an integral part of the framework of formal education. It also aims to train teachers on the application of the scientific method through applying innovative communication methods in workshops and research. This raises their professional skills and facilitates the activation of school clubs. The initiative works with selected school students as an activity outside of the school curriculum, and the activities take place during the school year.

The aim of the initiative is to help young pupils aged 4–16 years develop the skills of the twenty-first century, focussing on scientific knowledge, creativity, critical thinking, problem solving, and teamwork.

The initiative started with the academic year 2006/2007 and is still running today. It covered governmental schools affiliated to different Educational Departments in Alexandria, and hopes to involve the Go-

vernorate's school in accordance with the schedule set by the Library of Alexandria and the Ministry of Education in Alexandria Governorate.

Objectives of the project

- Working on the development of scientific thinking and innovation among students.
- Introducing the teachers to the new learning, experimental, interactive methodologies and taking advantage of global expertise in this area.
- Taking advantage of the scientific expertise and equipment presented in the Planetarium Science Center.
- Increasing the scientific and practical outcomes of the students.
- Developing the educational process and transforming it from a simple teaching tool into a new advanced learning method and practising developing scientific thinking among students.

Science clubs strategy

- Covered 300 governmental schools (primary and preparatory) from a total number of 1,122 schools in Alexandria according to the last statistics.
- The SCI targeted 1,000 students (as permanent students with regular visits to the Science Clubs). This number represents the average number of primary and preparatory school students who visit, interact and execute the science activities in

their school clubs with the teachers who were already trained at the PSC venue by the PSC team and the ToT (Training of Trainers) teachers involved in advanced training.

- The teachers training targeted an average of 2-3 science teachers from each school to guarantee the stability and the continuity of the project in each school.
- During the period 2010-2013, around 3,000-4,000 primary and preparatory school students were targeted (as temporary students who were involved in a number of activities conducted at the SCs). This is the average number of students who do not visit and interact with the club activities of the science club at their school on regular basis.
- The SCI targeted 1,000 primary and preparatory students (as permanent students with regular visits to the science clubs).
- Six ToT teachers who train the targeted schools with the PSC team.

During the implementation of the initiative, certain indicators are always considered in evaluating each school participating in the SCI, such as:

- Number of inquiries
- Participants' level of satisfaction or engagement (students in the school science club and teachers)
- Frequency of SCs follow-up visits
- Number of distributed resources

- Number of workshops held
- Usage rate of training tool kit and workshop tool kit
- Usage rate of distributed material
- Number of talented students discovered and how these students had been encouraged to participate in other PSC projects or activities
- Observable changes in the interests, attitudes, behaviour, skills, knowledge, and habits towards science of students and teachers alike.

Teacher training

The SCI provides training to the teachers who were selected from the targeted schools in each phase. The goal is to provide them with the necessary teaching skills, as well as the tools that enable them to create a science club in their schools. Also, it aims to train them on new strategies for changing the teaching methodologies and transferring the scientific information and concepts in an interactive way instead of via the indoctrination method. By the end of the first training sessions teachers will be familiar with a new concept of teaching entitled the Animator.

Teacher Training Methodology:

1. Pedagogical Philosophy, based on breaking the barriers of classroom and curriculum to provide space for creativity and innovation for both the teachers and the students, through the focal trainings of numbers 2-4.

2. Thinking Skills, offered through a minimum of three sessions to change the teacher’s concept of practical science lessons. Accordingly, by the end of the trainings, they will gain the capacity to transform theoretical scientific data to simple hands on activities that students can easily understand.

3. Six Teaching Methods: The training sessions will be conducted to inform teachers how to mix and match the various teaching techniques based on the students’ capacities and scientific content. These methods are as follows:

- 1) Read
- 2) Listen
- 3) Look

- 4) Listen and Look
- 5) Experiment, Perform and Do
- 6) Teach Others.

4. ToT: this advanced level will be offered to teachers to develop their training skills and inform them of the most successful and cost-effective training techniques.

- Over the past three years, 40 teacher training sessions were conducted, each session totaling 30 hours over 5 days for an average of 35 teachers, delivered by the Planetarium Science Center Coordinator and six teachers (core of ToT)
- Total number of trained teachers is about 1,400

Elementary Schools	Preparatory Schools
Two computers per school	Two computers per school
“Fun with Science” kits (contain 11 scientific fables in addition to scientific facts for every story)	Two scientific kits (Chemistry-Electronics) the content developing and the fabrication made by the project coordinator and scientifically revised by an academia
Scientific books containing experiments and activities to help the participants in each school to achieve and to realise a scientific project (such as scientific books donated by the USA Embassy in Egypt)	Scientific books containing experiments and activities to assist the participants in each school to achieve and to realise a scientific projects (such as scientific books donated by the USA Embassy)
	Two environmental kits (Green Box donated by Siemens)

Figure 1

In addition, educational tools and scientific kits were distributed to the selected schools to activate the clubs in each school (Figure 1).

Scientific websites list

The list includes scientific websites where teachers can find scientific information from trusted sources, e.g. the Arabic version of the LAMAP website; with innovative methods for teaching and simplifying different sciences such as mechanics, biology, or geology. The LAMAP website is one of the *Bibliotheca Alexandrina* projects to introduce these exceptional and tested resources for the Egyptian educational experience through a mirror website in the national language, and provide scientific content that is in line with the Egyptian education curriculum.

Website: <http://lamap.bibalex.org>

Fun with science training

Fun with Science Training for Teachers uses a series of fables written by Dr. Gunter Pauli containing messages that aim to develop children’s basic scientific understanding, and enable them to apply scientific knowledge as a creative tool. A major theme of the programme is the introduction of “systems thinking”.

The aim of this training is to present the basics of systems thinking, and the possibility of applying this methodology to the teachers who present it to their students.

- Fun with Science Programme Implementation: July 2009 - February 2014
- Target Group: Teachers of Science Clubs Initiative
- Attendees: Science Clubs trainees

Number of visitors to the PSC: Figure 2 presents the total number of PSC visitors, please note that 40% comprise the visitors from governmental schools.

Year	No. of Visitors to PSC
2008 / 2009	96,866
2009 / 2010	94,417
2010 / 2011	118,341
2011 / 2012	95,869
2012 / 2013	153,883

Figure 2

Introducing IBSE in an African Context: The Case of Sudan

Professor Mustafa El Tayeb

President, The Future University, Sudan

The sustainable development and progress of developed and developing countries alike depends on the availability of qualified and well-trained human resources, especially in the fields of science, engineering and technology. The task of preparing those resources has traditionally been the role of universities and institutes. However, it is becoming more and more evident that a large percentage of students reach university with a very low degree of understanding of scientific methods and the basic mathematical concepts. There is an urgent need to improve science and mathematics education in the schools.

The situation in Sudan is not an exception. Sudan used to have a recognised good system of higher education based on a few excellent universities. With the increasing demand for higher education, the government launched what is known as the higher education revolution in 1991. As a result of this initiative new universities were established in each state, raising the number to 32 universities. In addition to these public universities, Sudan now has 10 private universities. Moreover, there are now 20 public and 39 private university colleges.

This large number of institutions requires a corresponding number of teaching staff. However, due to what may be described as “exodus”, more than 3,000 qualified university staff have left Sudan seeking better working conditions in the neighbouring Arab countries.

On the other hand, the general education system is in bad shape and characterised by the following indicators: only 30% of the pupils in basic education have access to secondary education. 40% of those drop out before completing the third year. 47% of the teachers are not qualified because they are not graduates of teacher training colleges. Half of the teachers have never had any training during their careers. There is a marked deficit in the number and quality of math and science teachers. As a result, students who reach higher education show real weaknesses in these subjects. This makes it difficult for universities to train qualified scientists and engineers.

It appears from the above that there is an urgent need to train teachers on science and maths. This will likely improve the level of the students. Conscious of this, the Future University, a private university of technology, decided to tackle the problem of science education at schools. They have explored the various methods which are being used in different parts of the world, such as IBSE (France), STEM (USA), and Microscience (South Africa, UNESCO). The problems of science education

and the need for change are perfectly illustrated by the statement made by Bruce Alberts, the then President of the US National Academies: “Rather than learning how to think scientifically, students are generally being told about science and asked to remember facts. I am afraid not only students are taught that way but the teachers too were taught that way”.

Recently, an IBSE Workshop was held in Khartoum with support from the International Science, Technology and Innovation Centre for South-South Cooperation (ISTIC) and in collaboration with the *La main à la pâte* Foundation. The trainers came from Malaysia and from Philippines through the Regional Centre for Education in Science and Mathematics (RECSAM). In addition to the 30 participants from the 17 States in Sudan, 12 other participants came from Egypt, Ethiopia, Nigeria, Cape Verde, South Africa, Cote D’Ivoire, Kenya, Senegal and South Sudan. The aim of the roundtable was for the region to adopt inquiry-based education as policy and plan for teachers training on this style of education. The experts presented different approaches to IBSE.

Several international organisations and Academies participated in this event; this included the Islamic Educational, Scientific and Cultural Organisation (ISESCO), The World Academy of Sciences (TWAS), Sudanese National Academy of Sciences (SNAS) and the Egyptian Academy for Scientific Research and Technology.

International experts attended the Roundtable and the Workshop, including: Prof. Adnan Badran, former Prime Minister of Jordan and former Deputy Director-General of UNESCO, Prof. Bruce Alberts, former President of the National Academies, USA, Prof. Yves Quéré from the French Academy of Sciences and the *La main à la pâte* foundation, Prof. Alec Boksenberg, Cambridge University, UK, Dato Lee Yee Cheong, ISTIC, Malaysia and many others.

The most important sign of progress was the presence of the Minister of Education, not only during the opening ceremony, but also throughout the Roundtable and the training workshop.

From the experiences of other countries, we know that the introduction of IBSE takes time. It also requires continuous support for its sustainability. It is for this reason that the presence of high-level personalities was necessary; it served to send the message that IBSE is an important matter. We also made sure that there was adequate media coverage to sensitise the public about IBSE. All these efforts ensured the success of the introduction of IBSE in Sudan. The teachers unanimously endorsed the IBSE approach and promised to train their colleagues.

Follow-up

Conscious of the fact that the success of this initiative requires close follow-up actions from all the partners, the univer-

sity decided to coordinate the follow-up actions.

To this end, the university organised a meeting of all the partners, including representatives from the federal Ministry of Education, the National Commission for UNESCO, UNESCO Cairo Office, Sudanese National Academy of Sciences, and the trainees, respectively. The Minister of Education of the State of Khartoum and the President of the Future University chaired the meeting. Each partner decided to take concrete actions.

One year on, we list below some of the results of actions taken by the partners:

- The Federal Minister made an extraordinary effort and obtained funding for science teaching from the Ministry of Finance. The Minister increases the percentage of pupils studying science from less than 29% up to 37%.
- Three states initiated IBSE activities (Kordofan, Darfur and White Nile States) and started working for IBSE teachers training.
- The SNAS organised a pilot project in the Gaddarif area to introduce IBSE in a rural school.
- The Future University decided to organise a second international training workshop on IBSE. The University also decided to raise awareness

among the other universities about the importance of IBSE.

Lessons Learnt

From this experience, it was clear that IBSE is a long journey; its introduction requires a sustained effort by all concerned. There is a need to motivate the teachers and to encourage them to adopt the IBSE approach. Linking trained science teachers in a network is highly recommended; this may allow them to share experiences and to form a community of practice.

The Way Forward

IBSE has been promoted by academies of science worldwide. We believe that the time has come for ministries of education to take over. For this to happen, UNESCO must take the lead. It should be recalled that the organisation has, since its creation, promoted science education by publishing a number of manuals and teaching materials. For example, the UNESCO Source Book for Science Teaching, War-Devastated Science Laboratories, Inventories of Apparatus and Materials for Science Teaching and a bilingual text on a collection of designs of apparatus and materials for schools. At an earlier stage, UNESCO supplied large boxes of workshop equipment needed to make apparatus for teaching science. It would therefore be natural for UNESCO to take the lead and adopt IBSE as a flagship project.

On Opportunities for Improving Science in Schools in Sudan

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Background

Sudan has been ruled as a one party state since July 1989. Administratively, it is a federal state divided into 18 units (states), where each unit is further divided up into 5-7 localities (Mahaliyas). The responsibility for general education is shared by the federal government (Federal Ministry of General Education (FMOGE)), the states (Ministry of Education) and the Mahaliyas. The responsibilities of the FMOGE include formulating general policies, plans, programmes, and curricula, and training of teachers and educational administrators. States, on the other hand, are responsible for the management and funding of general education.

General education in Sudan is comprised of three stages: pre-school (2 years, starting at 4 years of age), basic (8 years, starting at 6 years of age) and secondary (3 years, starting at 14 years of age). A salient feature of general education is that the curriculum has always been nationally mandated. Moreover, curriculum reform can only be initiated and implemented by the FMOGE.

School science

Major characteristics of school science in Sudan are:

- Science is defined as traditional natural sciences (earth and space sciences not included)
- Science education starts in G4
- No labs or experiments
- Human-made world is largely absent from the curriculum
- The main source of school teachers of science are Faculties of Education (totaling 26, one each in 26 different public universities)
- Teacher-centred approach to instruction

Obviously, school science needs to be reformed rather urgently. However, in view of the nature of the regime and the organisation and management of general education noted earlier, it is practically impossible for SNAS or any independent entity concerned with education to initiate a meaningful reform of school science. Nonetheless, I suggest that SNAS may initiate work in three different, but related, areas that would impact school science significantly in the long term.

First, noting that at present there is no national curriculum for pre-school education, SNAS may design a suitable science curriculum for this stage and pilot it in one or more states. Indeed, there are a few states who would be eager to adopt and implement such a curriculum.

Second, there is evidence that many science teachers, especially outside major cities, would welcome the opportunity to learn about and be trained in IBSE. SNAS may plan and implement a series of workshops in selected states for this purpose.

Third, universities are independent of FMOGE. SNAS shares a strong interest in improving science education in the country with many academics in Faculties of Education in public universities. SNAS may initiate a dialogue with these academics and organise seminars or conferen-

ces about the training of science teachers. The effectiveness of SNAS in undertaking the proposed activities would be enhanced significantly if it would involve other major stakeholders, such as professional societies and state ministries of education.



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Summary of the Royal Swedish Academy of Sciences' School Activities

Professor Per Olof Hulth

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The Royal Swedish Academy of Sciences (RSAS) was founded in 1739 by Carl von Linné, among others. Today the Academy has approximately 450 Swedish and 175 foreign members. The Royal Swedish Academy of Sciences is an independent, non-governmental organisation with a charter that, in its first article, defines its function as: *“to promote the sciences and strengthen their influence in society”*.

The Academy awards the Nobel Prizes in Physics and Chemistry.

The Academy has a strong interest in science education and has established a permanent committee for education chaired by its 3rd vice president. The committee consists of Academy members and school experts as well as teachers. There are several activities with the aim to strengthen the science teacher's working situation. One is the “Inspiration Days for Teachers” where members of the RSAS, together with other prominent scientists, visit different cities in Sweden to give a full day of lectures for teachers. Topics are e.g. “Big Bang in the Universe and Particle Collisions in Accelerators”, “The Origin of Life and Evolution”, “Planets and Life in the Universe”, “The Front

Lines in Medical Research” or “The Climate of Earth – A Complex System”. These events also stimulate informal interaction between scientists and teachers.

An important recognition of teachers is the Ingvar Lindqvist prizes awarded every year to teachers who through their enthusiasm, new ideas and inspiring work awaken their pupils' interest in mathematics, physics, chemistry and biology. Any teacher or student in Sweden has the opportunity to nominate a candidate. A special prize committee evaluates the nominees and the Academy decides on the final choice of laureates at a general meeting. As for the Nobel Prizes, the Permanent Secretary calls the laureates just after the decision has been made. H. M. King Carl XVI Gustaf presents the prizes at the Academy's annual meeting.

The largest education project is “Science and Technology for All” (*Naturvetenskap och Teknik för Alla* (NTA)) which is a school development programme initiated by the Royal Swedish Academy of Sciences and the Royal Swedish Academy of Engineering Sciences in cooperation with municipalities throughout Sweden. The objective is to support teachers in compulsory schools (grades K-9) in working with Science and Technology in their classrooms, and to apply IBSE from first grade onward. The NTA programme started in 1997 as a result of contacts and cooperation between the National Academy of Sciences (NAS) in the USA and

RSAS. An initial 10-year contract for the use of NSRC (National Science Resource Center)/STC (Science and Technology for Children)-material in Sweden was signed by RSAS and NSRC/Carolina Biological Supply Company. The programme has been financed by the Swedish Ministry of Education and Research and various private funds.

At an early stage, school organisers (in Sweden mostly municipalities, independent schools or their organisations) were offered the opportunity to participate in the NTA programme. The decision to join the programme is taken at the highest level within the respective school organiser, e.g. a municipal board. A mutual letter of understanding is signed. There should be a NTA coordinator in each member organisation. Costs for coordinators, materials, and teacher training are covered by the member organisation. Support for long-term school development is given by the central NTA organisation.

After the first few years, the programme now grows at a steady rate of 10 or more new members of the union per year. At the moment (May 2014) the union has 116 municipalities (out of a total of 290) and 28 independent school organisers as members. More than 180,000 students and 10,000 teachers are working with the programme each semester. Since 1 July 2013 the programme has been run by the NTA organisation itself, in which the Academies are board members and responsible for the NTA scientific committee.

Any lasting positive contribution to school development must be long term. In many countries it takes nine years to complete compulsory school, and in order to have an impact the programme must comprise a significant fraction of a generation and school levels before a proper evaluation can be made.

The Board of NTA has recently decided to start an independent evaluation of the project, which will be completed in the coming year.

Bringing Inquiry Learning into Practice

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Academy of Sciences Malaysia

In 2012, the Academy of Sciences in Malaysia undertook a two-year pilot study on IBSE based on LAMAP techniques. The pilot study involved 346 pupils in four primary schools. The schools were selected by the District Education Office, which approved the pilot study on the condition that it does not interfere with the implementation of the existing school curriculum and school management. A briefing was held for the school heads and other education personnel on the pilot.

The objectives of the pilot study were to assess teachers' understanding of IBSE pre- and post-training; to ascertain teachers' capability in IBSE and in developing science process skills among pupils; to assess pupil's performance in science (science process skills and problem solving) and to see if there has been any behavioural change among pupils in terms of motivation and interest in science at the end of the pilot study.

Four science teachers from each of the four schools were given a one week training workshop on LAMAP techniques by the Southeast Asian Ministers of Education Organisation (SEAMEO) Regional Centre for Science and Mathematics. A project manager was appointed to monitor teachers' use of LAMAP in the

classroom and to provide assistance and advice. The monitoring sessions involved classroom observations, and focussed on how the lessons were conducted, activities carried out, pupils' participation as well as resources and materials used. Discussions with teachers were held after each observation. A session was organised by the Academy of Sciences after the first year of the pilot study. The initial feedback from teachers was very positive, and they felt pupils enjoyed the new learning techniques. They also pointed the need for more training workshops to be conducted in addition to the one-week training; although it was very useful and provided them with many ideas, it was not sufficient. As a result, four more training workshops were organised on a monthly basis to provide more in-depth experience with using IBSE in class.

Data on the pilot study was collected through lesson observations, feedback sessions, interviews with teachers, teacher's questionnaires, teacher's reflections schedule, semester test results, pupils science books, informal pupil interviews, as well as science carnivals. Findings of the pilot study showed positive results for teachers and pupils and for the overall science performance. Teachers had a better understanding of IBSE after the training workshops; they were able to carry out IBSE based on the LAMAP approach; there were more pupil-oriented teachers; teachers asked more challenging and open-ended questions; they

used diversified learning materials; they encouraged collaborative learning; they involved pupils in getting ideas on how to test and provide answers to their questions through investigations; and they listened to pupils' ideas. Teachers felt the workshops had enhanced their knowledge of IBSE and gave them confidence, made them more creative, and they were happy to be involved with the pilot study.

In terms of pupils, it was found that IBSE had enhanced their motivation and interest in science. They were actively involved in performing the experiments either on their own or with colleagues, and they participated in discussions and were able to explore and explain results. Teachers noted that the pupils showed more interest in learning science. During the science carnival organised at the end of the pilot study, it was observed that the pupils involved were able to carry out the activities according to the principles of IBSE, such as identification of problem; statement of hypothesis; planning, design and protocol of experiment, carrying out experiment and confirming/rejecting hypothesis; final conclusion, and recording and communicating results to others. The winners were from the group taught by teachers who attended all training workshops. They were better organised, systematic and succeeded in their first attempt.

Another positive outcome of the pilot was on science performance. An analysis

of the semester test results in the five major subjects taught: science, mathematics, English, Bahasa Malaysia 1 (Malay 1- Comprehension) Malay 2 (Writing); showed that mean science scores had improved from 46.6 in 2012 to 58.0 in 2013. Its position in relation to other subjects had also improved from 5th (last) position to 3rd position. There was also increased correlation between science and the various subjects at the end of the pilot study.

There were several challenges faced during the pilot study: the difficulty in getting pupils to record and write in the science notebooks; the wide syllabus which needed to be covered affected the time that should be spent on investigations and experiments; and teachers also found that teaching topics which are too theoretical are difficult with IBSE. Teachers had problems arousing pupils' curiosity, especially the weaker ones, and found difficulty in getting responses from them. Teaching was very much teacher-centred in these classes and some teachers still depended more on the textbooks and were unwilling to go beyond that. There was also an element of reluctance to fully try out IBSE in class. Many teachers felt the examination answer schemes, which teachers were required to adhere to were rigid, thus not quite in line with the principles and philosophy of IBSE.

What were the lessons learned from the experience of the pilot? There are several factors that could affect the implemen-

tation of IBSE of which time is an important element. IBSE requires sufficient time to allow for the different phases of activities to be carried out. The content of the school syllabus and the pressure to complete the syllabus early on in the school year also has an influence on the full use of IBSE in teaching. An effective implementation requires teachers to be creative and confident for the activities to challenge the minds of pupils. The pilot also pointed out the importance of giving professional support to teachers from all stakeholders; teachers need continuous professional support and a one-time training workshop is not sufficient to equip them with the required skills, knowledge, confidence and creativity to have an effective IBSE in class. Engaging with the

various stakeholders, particularly with Ministry of Education personnel, was found to be of great importance.

Teachers felt that IBSE is the way forward in the teaching and learning of science because it creates motivation, interest and excitement in learning. They also felt that IBSE is relevant to the new emphasis on the development of higher order thinking skills by the Ministry of Education. IBSE is also said to be a feasible and inexpensive approach to implement as it mainly uses cheap and recycled materials. The pilot teachers pledged that they will continue to use IBSE in their lessons and recommended that IBSE should be continued for wider implementation.



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The BT Young Scientist & Technology Competition and Exhibition — Ireland

Professor Peter Mitchell
Royal Irish Academy

The BT Young Scientist & Technology Competition and Exhibition, which celebrated its 50th anniversary in January 2014 – making it one of the longest standing exhibitions of its kind in the world – was the brainchild of two academic researchers, the Rev Dr. Tom Burke and Dr. Tony Scott, from University College Dublin. In 1963 the two physicists came across the concept of “Science Fairs” while conducting research in New Mexico (USA). There, local school science exhibitions culminated in “State Fairs” and ultimately a national competition. The pair believed that this hands-on approach to science was something that Irish students could really benefit from by taking science outside the four walls of the classroom and demonstrating that science is ever present all around us. And so was born Ireland’s Young Scientist & Technology Exhibition, which has thrived ever since.

The first competition was held in 1965 in the official residence of the Lord Mayor of Dublin and attracted 230 entries. Interest in the first event was such that the exhibition moved to the larger venue of the Royal Dublin Society in 1966 and has remained there to this day. The 2014 exhibition proved to be one of the largest to date with 2,000 projects by 4,418 students

from 379 secondary schools submitted for consideration (representing 50% of all such schools in Ireland). All entries were screened and 550 projects involving over 1,200 students were selected to compete at the exhibition. The event attracted an attendance of over 45,000 people.

The early exhibitions involved individual students competing against one another, but in 1976 “Groups” were introduced for the first time. Many other developments have taken place over the 50-year history of what has become a highly valued all-Ireland institution, including the welcome participation of schools from Northern Ireland for the first time in 1972, the addition of a “Technology” category in 1998, and the introduction of a Young Scientist “Boot Camp” in 2010. 1989 also saw the first year of the EU Contest for Young Scientists; indeed, winners of the Irish exhibition have gone on to win 14 first prizes during 24 years of the EU Young Scientist Contest, and collected over 20 top awards in the International Science and Engineering Fair in the USA – testimony to the high standards expected of, and achieved by, the exhibitors.

The competition is open to all second level students from Ireland, North and South, who are aged between 12 and 19 years, and is divided into three age categories, junior, intermediate and senior. A student can enter as an individual or share the work as a group, where the latter is defined as comprising not more

than three people from the same school and age category. The exhibition comprises four project categories, namely: Chemical, Physical and Mathematical Sciences, Biological and Ecological Sciences, Technology, and Social and Behavioural Sciences. There are over 120 prizes to be won, including industry-sponsored travel awards, educator of excellence awards and special awards including, of course, the prestigious Young Scientist & Technologist(s) of the Year Award together with a cheque for €5,000.

Each project is judged at least three times by three different judges. The judges can only spend about 15 minutes at each stand and they start by asking the student to tell them about his/her project and then proceed to more specific questions. Essentially, the judges focus on how well the student(s) have followed scientific methodology, the detail and accuracy of the research as documented in the student’s report book and diary, and whether experimental procedures have been used in the best possible manner.

The 2014 winner, Paul Clarke (aged 17), took the top prize for his project entitled “Contributions to cyclic graph theory”. Paul was entered in the senior section of the Chemical, Physical and Mathematical Sciences category, and will represent Ireland at the 26th European Union Young Scientist competition, which takes place next September. As this year’s winner, Paul also wins a once in a lifetime trip to

Silicon Valley in California, where he will enjoy a hosted tour of leading enterprises and meet business leaders from the world of science and technology.

Industry in Ireland, indigenous and multi-national, has strongly supported the Annual Young Scientist & Technology Exhibition from the outset. For the record, the lead sponsor of the first event in 1965, and for many years thereafter, was Aer Lingus, the Irish national carrier. Today, we see the highly beneficial support of the ICT and Biotech sectors, stakeholders with an active interest in the reform of science education.

The BT Young Scientist Business Bootcamp is now in its 5th year. This four-day innovation and skills camp welcomes 29 second-level students from across Ireland who demonstrate an ability to understand how and why a simple idea can be developed into a commercially viable enterprise. The students are selected each January from the cohort who competed in that year’s Young Scientist & Technology Exhibition. The Bootcamp, delivered in partnership with University College Dublin, takes place on the latter’s campus at NovaUCD, and aims to bridge the gap between education and business for students who demonstrate entrepreneurial flair and business acumen.

Last year it was announced that the Royal Dublin Society’s Primary Science Fair would be returning to the Young Scientist

& Technology Exhibition for 2014. The Fair is an integral part of the exhibition and, although not part of the main competition, it provides a public forum for primary schools across Ireland to showcase their class “STEM-style” projects, receive feedback from experts in the field, and learn from viewing other projects at a major exhibition. Each year, 120 places are available to schools that would like to exhibit a class project at the Fair during the three public days of the main exhibition.

Feedback from students and teachers who have participated in the exhibition over the years indicates that it is seen by students as highly beneficial in helping to develop a deeper appreciation of science and technology, a great opportunity to showcase their own bright ideas in subject areas that are essential to future prosperity, and a great extra-curricular activity to put on one’s CV or application form for entry to third level education. The exhibition removes science from the more formal setting of the classroom or laboratory and into a fun environment where students can present their very own projects to the many thousands of visitors who come to experience the enthusiasm and innovation so palpable at this annual festival of science.

For schools, participation in the event helps to highlight their commitment to the key subjects of science, technology, engineering and maths (STEM), with all the positive publicity that this brings.

Taking home one of the many awards is viewed as a strong endorsement of a school, its staff and its pupils. Moreover, a school that is active and successful in this annual festival impresses prospective parents.

IANAS SEP and the “HaCE” Programme

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IANAS, the Inter-American Network of Academies of Sciences, (the Americas’ regional network of the IAP, the Inter-Academic Panel), was created in 2004 to support cooperation towards the strengthening of science and technology as a tool for advancing research and development, prosperity and equity in the Americas. The IANAS Science Education Programme (IANAS SEP) comprises at present 19 Academies of Sciences, and its major objective is to improve the quality of science and technology education in the region by developing IBSE, mainly in primary and secondary schools.

The Academies share a single goal: to provide teachers and students with the wonderful experience of discovery in science and technology by using the IBSE methodology, and cooperate in improving the quality of science education in the schools.

The low results of the Latin American students in the PISA examinations are well known, but there are other examinations carried out by UNESCO. Data shows the academic achievements in mathematics in the “Second Regional Comparative and Explanatory Study” (SERCE) achievement

assessment (Source UNESCO-OREAL 2008). It can be observed that students from very few countries achieved level 4, and several are even below the minimum required level of understanding (level 2).

The Argentine Academy of Sciences (ANCEFN) has been a member of IANAS SEP since 2004. The Committee, which meets every year, is constituted by all Focal Points for every Academy of Science. A Portal site called “IndagaLA” has been implemented to share pedagogical resources in the region. It has been led by the Mexican Academy of Sciences since 2010.

The “HaCE” Programme (from “*Haciendo Ciencia en la Escuela*”= Doing Science at School) was developed by the Argentine Academy of Sciences (ANCEFN) for the training of teachers in the IBSE methodology. Though there is widespread recognition that citizens should have a basic understanding of the fundamental concepts and procedures of science and technology, they are scarcely or poorly taught in the schools. Teachers usually complain of the lack of interest in science on the part of their students, they are used to rote learning, since the STEM concepts are not being taught as fundamentally connected to his/her daily life. IBSE education encourages creative thinking, teamwork and problem solving; it develops solidarity, respect for the other, learning to defend one’s own reasoning and ideas, and listening to and discussing different opinions. It can also lead people to learn to appreciate natural resources

and become aware of the relevance of sustainable production and consumption as well as climate change.

To reverse students' lack of interest in science, the "HaCE" programme of the ANCEF N implements IBSE methodology in the national public schools by developing pedagogical resources and workshops for the training of teachers.

The programme first started at the primary level; since 2009 it has also been applied to the secondary level, and workshops for technical schools have been implemented since 2011. The HaCE programme is based on: a) training "facilitators" for an integral STEM education based on the experimental evidence and the inquiry, b) having the facilitators conduct workshops to train and coach the teachers to implement IBSE with the children in the classroom, and c) developing experimental modules (pedagogical resources) with cheap and easily accessible materials for every school.

The IBSE ("HaCE") work in the classroom creates, as in science labs, a community of inquiry where students engage directly and intellectually in the practices of science. They experiment and interact with each other as co-inquirers into phenomena and participate in critical but friendly discussions and arguments in pursuit of scientific understanding, explanations and developing causal reasoning.

The "HaCE" team is mainly formed by young graduate students from the National University and experienced secondary school teachers. It has widely benefitted from international cooperation, especially at the beginning. Special thanks are due to the LAMAP Foundation, which allowed free access to its pedagogical resources. The free implementation of training workshops (WS) and pedagogical resources for the primary and secondary level are the basis for the whole sustainability of the programme. Several didactic materials have been developed and published. Specially devoted to public and modest schools, the "modules" are designed to be used in schools with no laboratory facilities, and with economic and easily accessible materials. Led by academicians, professional scientists are engaged in guaranteeing the quality of the modules. A book containing near 40 pedagogical resources for primary and/or secondary schools has been available since 2012 and is freely distributed to schools.

Pilot Centres

Argentina is a large country and several Pilot Centres have been implemented since 2010, mostly in the North of the country where many vulnerable schools and communities are located.

Recent Achievements

The programme has intended to implement the spirit of recent documents, many of them related with the "eradication of poverty" and the "access to education for

all". Thus, the IAP Letter from Rio (2013), the Global Grand Challenges (2013), and the UN Sustainable Development Goals post-2015 agenda are among the subjects to which the programme is committed. An IberoAmerican Symposium on "STEM Education by Inquiry" is currently being organised as a satellite to the IBERSCIENCE2014 (OEI) and will be held in Buenos Aires on 13 November 2014. The symposium is devoted to improving the quality of the STEM education, examining ways of leading youngsters towards becoming capable of crossing boundaries when dealing with global problems, and helping

society become aware of the relevance of scientific literacy and culture to help social promotion, promote cooperation and build peace among communities.



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The Programme “Scientiam Inquirendo Discere” (SID)

A Model of Collaboration between the Accademia Nazionale dei Lincei, the National Association of Natural Science Teachers (ANISN) and the Ministry of Education to Introduce IBSE in the Italian School System

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The problem of inadequate school performances of Italian students in science and technology has been evidenced by Italian national and international surveys (TIMSS, PISA). The improvement of science teaching starting in primary school is considered a very important task for contributing to the development of students' capabilities and scientific attitudes. Teachers are key players in the renewal of science education. To improve scientific education in Italy, which until today has not had a national strategy for its promotion, a systematic and permanent teacher training initiative is considered necessary in order to change the school science-teaching pedagogy from mainly deductive to inquiry-based methods.

The programme *Scientiam Inquirendo Discere* (SID) is a systematic model of IBSE introduction, implementation, and dissemination in Italy. It started in 2011 as a collaborative National Programme between the *Accademia Nazionale dei Lincei* and the National Association of Natural Sciences Teachers (ANISN), supported by the Ministry of Education. SID is based on experiences and results of the participation of ANISN in the Fibonacci Project, in strong cooperation with the French *Académie des Sciences* and the LAMAP programme as well as with other European teams.

Primary and lower secondary school teachers are the main SID targets. SID achieved important strategic objectives: enhancing and profiting from previous experiences and initiatives developed in Italy, strengthening international collaboration and providing a tool for the implementation and evaluation of the national guidelines for the curriculum. SID is coordinated at national level by representatives of the Italian Association of Science Teachers and by representatives of the *Accademia dei Lincei*. The operational local nuclei are called “SID Pilot Centres”. They consist of networks of schools in which selected science teachers are involved in the promotion of the renewal of science education, following the IBSE methodology.

In the last three years seven pilot centres, hosted in prestigious research centres or

local Academies, have been created. SID main activities have consisted of:

- 1) Regular in-house training courses for teachers both at local and national level;
- 2) Peer to peer support actions in person and online;
- 3) Development of didactic and experimental resources;
- 4) Twinning;
- 5) Planning and implementation of evaluation tools.

The ambition of SID is to organise and support permanent teacher training reference centres that contribute to the dissemination of the IBSE approach through didactic research and assessment tools, involving teachers from primary to lower secondary school and aimed at promoting, through specific actions of in-service teacher training, a long-lasting and effective change in science education in Italy.

The building of the SID model was enriched by the cooperation with other European teams in the Fibonacci Project of the FP7, especially thanks to the twinning strategy and the field visits by ANISN as www.fibonacci-project.eu partners (Harlen & Allende, 2009; Artigue et al., 2012). SID has a multilevel organisation structure that requires the constitution of both national advisory and operatio-

nal nuclei called “pilot centres”. The pilot centers are defined by their willingness to provide structural, organisational and human resources, their experience of working within other initiatives and partnerships with networks of schools and promotion of community practices in science. The national responsible presides over the SID National Steering Committee that organises all the national training activities, coordinates SID pilot centers, and establishes the guidelines of didactic research and of SID assessment (Borda Carulla, 2012).

SID is different from Italian traditional in-service teacher training initiatives because of:

- commitment time: during one year an experimenting teacher dedicates more than 40 hours to the project and a trainer dedicates about 120 hours;
- teachers' participation, which is built on a network of local, national and international structures;
- scientific support, which is provided mainly by scientists and by experienced teachers;
- development of theoretical and experimental materials;
- analysis and evaluation of training.

In three years some of the key objectives of the model have been achieved:

- 1) The synergic cooperation between Accademia dei Lincei and ANISN.

2) The construction of the “pilot centre” model.

3) The establishment of seven pilot centres, namely in Naples, Rome, Pisa, Venice, Milan, Turin, and Bari. They are hosted at Stazione Zoologica Anton Dohrn in Naples, Accademia dei Lincei in Rome, Scuola Normale Superiore in Pisa, Istituto Veneto in Venice, Istituto Lombardo in Milan, Accademia delle Scienze in Turin and University of Bari. In the school year 2013-2014 the seven active SID pilot centres’ activities have involved about 20,000 students.

4) The choice of the actors and the creation of the school networks. Each pilot centre’s activity is programmed by an academician and an ANISN teacher. The “core” group of trainers and experts as well as teachers are selected on the basis of their previous experience in science teaching. The main targets of the programme are comprehensive schools with teachers of kindergarten, primary and lower secondary schools. After three years the effective power within the same school was a clear outcome.

5) A low growth strategy to ensure quality and long term sustainability and a very effective twinning strategy at different levels.

6) The development of free of charge shared resources (theoretical, methodological, experimental) and a shared training and activities plan.

7) The teachers support in classroom activities via peer to peer observation and/or support of trainers, experts and scientists.

8) The formative assessment represents a crucial point in the IBSE approach and SID. All SID activities and the training model developed will be assessed both by internal and external (European) evaluators through assessment tools and on-site focus groups.

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Primary Connections: Linking Science with Literacy

Shelley Peers

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Development

Australian Academy of Science

“Primary Connections” is the national primary school science education programme of the Australian Academy of Science. It is in use, in one way or another, in over 70% of Australia’s 7,640 primary schools, potentially impacting 90,000 teachers and 1.4 million students. Launched in 2004, its development has been funded by the Australian government, and Australian 2011 Nobel Laureate, Professor Brian Schmidt, donated \$100,000 of his Nobel Prize money to the programme.

The programme is a new approach to supporting teachers. It is inquiry-based, helping students to ask meaningful questions and to learn how to find answers in a scientific manner. It focusses on teachers’ confidence and their ability to teach science and literacy. This is the focus of the programme because research shows that teacher quality is the single most important school-based factor affecting student learning outcomes. The comprehensive approach consists of a professional learning programme, and 31 award-winning teaching units (which are aligned to the Australian curriculum). These are now freely available online to all Australian teachers.

The website has assessment rubrics for all units, background information on science concepts, a unit template for teachers to develop their own units, and the results of research and evaluation (over 20 independent reports). Equipment kits can be purchased from an endorsed external supplier.

The programme is based on the research literature in the field. It links science with literacy and promotes evidence-based reasoning. It incorporates critical and creative thinking and collaborative teamwork. The units of work are much more than a set of activities; they have a sophisticated instructional design based on the 5Es teaching and learning model: Engage, Explore, Explain, Elaborate, and Evaluate. The units are all trialled in schools, and prior to publication they are redrafted based on teacher feedback.

However, the success of Primary Connections is not just about the units, it is about focussing on support for teachers rather than activities for students. It is about teachers changing the way they think about teaching science. The professional learning programme and the units both address the key challenges for teachers: their fears and their skill levels. Primary Connections addresses teachers’ lack of confidence, limited science knowledge, inadequate pedagogical strategies for science and restricted familiarity with messy materials and complex equipment, as well as anxiety over unexpected students’ questions.

We have found that high level advocates have been very effective in lobbying for government support and in encouraging ongoing commitment to initiatives rather than having stop-start funding for programmes.

The Australian Academy of Science has been involved in science education for over 50 years and enthusiastically supports IBSE at all levels. We would be interested in engaging in partnerships to help develop and support IBSE approaches.

The Australian Academy of Science has four education programmes:

Primary Connections: “linking science with literacy” – is an inquiry-based primary school science programme that aims to improve teachers’ confidence and skills in teaching science from Foundation to Grade 6.

Link: <https://primaryconnections.org.au/>

Science by Doing – is an inquiry-based programme of professional learning and online curriculum units for Grades 7-10 that aims to increase student engagement with science and support school-based science teaching teams.

Link: <http://www.science.org.au/science-by-doing>

Nova – science in the news – provides accurate and up-to-date information on scientific, mathematical, health and en-

vironmental issues in the news to make scientific information accessible to science teachers, journalists, and the general public.

Link: <http://www.science.org.au/nova-science-news>

Interviews with Australian Scientists – develops transcripts of interviews with outstanding Australian scientists with accompanying teachers’ notes available online.

Link: <http://www.science.org.au/interviews-australian-scientists>

Dutch Science Education Hubs: Collaborations between the Academy, Universities, and Primary and Secondary Education

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Professor Carl Figdor

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Abstract

Since 2009 universities in the Netherlands have a science education hub (SEH). An SEH can be described as a network of a university, schools for primary education and an intermediary organisation such as an expertise centre, teacher academy or science museum. Young researchers and (upcoming) teachers work together on developing programmes for primary schools. The main goals of these SEH are to promote science education in primary schools and to make scientific knowledge accessible for primary education. Although each SEH has its own accents regarding goals and activities that fit within the major objectives of the Orion programme, most SEH use IBSE as a leading pedagogy in their projects.

Science education in the Netherlands

Recent reports, such as the report of the exploratory committee Science and Technology 2013 and the results of TIMMS

and PISA about the state of science and technology in primary education, show that the amount of time allocated to science and technology is very low, i.e., only 4%, compared to an average of 10% in other countries. When teachers teach science in the classroom, it has in only 5% of cases been done through the inquiry process and 13% of the children never perform experiments in the classrooms, although we see this percentage rising. Furthermore, only 3% of the children score at excellent levels, the majority of the scores of the children are clustered around average rates.

National STEM Platform

Since 2004, there has been an action plan called Delta Plan in order to address shortages in STEM experts. This plan was drafted by Ministries of Education, Economic Affairs and Social Affairs. The four key strategies are: interesting programmes, appealing jobs, interesting options and attractive business climate. The implementing agency is the National STEM Platform “BètaTechniek”, Bèta Technology.

Orion programme

One of the programmes of the National STEM platform concerned with primary education is the Orion Programme. The Orion Programme is a network of SEH. This programme has made it possible for universities to initiate an SEH. From 2009 until 2012, each university received funding sponsored by the Dutch STEM platform. After this period, five universities

and two consortia of two-three universities received follow-up funding by the Dutch STEM platform from the Ministry of Education, Culture & Science and the Royal Netherlands Academy of Art and Sciences (KNAW) for an additional four years.

Science education hubs

An SEH can be described as a network of a university, schools for primary education and an intermediary organisation such as an expertise centre, teacher academy or science museum. Young researchers and (upcoming) teachers work together on developing programmes for primary schools. Goals of the science education hubs are to:

- Promote science education in primary schools;
- Make scientific knowledge accessible for primary education;
- Share best practices regarding science education and especially IBSE with primary education and within the Orion programme;
- Encourage the scientific attitude of young children (age 9-13);
- Professionalise (pre- and in-service) teachers in IBSE;
- Develop teaching materials and methods;
- Develop lessons by scientists for children;
- Generate knowledge about best practices, IBSE, and teacher professionalisation by research;

- Coach scientists as to how they can translate or present their scientific topic to the public.

Although each SEH has its own accents regarding goals and activities that fit in the major objectives of the Orion programme, most SEH use IBSE as a leading pedagogy in their projects.

Examples of activities executed by most SEH:

- Invite children's colleges to the university; for example, organise lectures followed by a circuit of activities related to the topic, so children can do hands-on activities and experience how science works.
- Invite scientists to visit classrooms.
- For example, at the 90th anniversary of the Radboud University, in one day, 90 professors visited in toga, 90 schools in the region of Nijmegen. Lectures were given to 90 classes.
- Provide courses for PhD students and other young scientist on how to make their topic understandable to a broad public. For example, Radboud University has a course to help young scientists learn how to present their topics to children. At the end of the course, they visit a school and organise a science afternoon in which they give a presentation and do a science quiz and experiments with children.

- Provide professional development courses for teachers in IBSE.
- Hold an annual professionalisation-day for science education for teachers, called Science and Technology Academy or Winter school; for example, the programme of the annual Winter school of the Radboud University consists of lectures by professors followed by hands-on workshops for teachers on how to do experiments with the topic of that lecture in the classroom.
- Propose IBSE projects or design-based learning in the classrooms, using the design cycle to develop a solution for a problem.
- Manage collaborations between

scientists and schools to develop IBSE projects based on scientific topics.

- Perform research towards effects of professionalisation courses.

Besides activities, the SEH also develop materials for the professionalisation for teachers. Examples of these materials are:

- Inspiration books with best practices of a range of IBSE topics and projects
- Lessons for science education and how science works
- Video clips illustrating projects in the classrooms
- Posters of the steps of the inquiry cycle



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For more information or inspiring examples, visit the following websites:

<http://www.wetenschapsknooppunten.nl/home.html> [website of all SEH]

<http://www.platformbetatechniek.nl/> [website of the national STEM platform]

www.wetenschappelijkedoorbraken.deklasin.nl or www.wetenschapdeklasin.nl [website with video clips of IBSE projects of the SEH of the Radboud University Nijmegen, called WKRU]

Case Study: Science Education Hub Radboud University

The annual programme “Scientific breakthroughs into the classrooms” consists of the following activities: Radboud Science Awards, Start project teams, IBSE projects in schools, and the annual book ‘Scientific breakthroughs in the classroom!’.

Radboud Science Awards, Start project teams

Each year, the SEH of the Radboud University honours three researchers with the Radboud Science Award, a prize for the best scientific research at the Radboud University. In interdisciplinary teams, scientists, (pre-service) teachers, and members of the WKRU (science education hub of the Radboud University Nijmegen) collaborate for one year to translate the topics into meaningful research activities for primary school children. Current societally relevant and excellent scientific

research results of the Radboud University Nijmegen are the leading themes in the development of these activities.

IBSE projects in the classrooms

The pedagogical approach of IBSE is leading in the translation of the research topics. For each step of the research cycle activities are developed and performed in the classrooms. Open IBSE consists in the Netherlands of the following steps:

- 1) Introduction/confrontation
- 2) Exploration
- 3) Designing an experiment
- 4) Conducting an experiment
- 5) Concluding
- 6) Communicating
- 7) Deepening/ broadening

Good practices in the book series “Scientific breakthroughs into the classrooms”

After the project, each project team writes a chapter in the upcoming book consisting of a description of the scientific breakthrough by the researchers, and descriptions of the various activities that have been conducted in the classrooms for each step of the inquiry process by the teachers. The video clips of the projects can be seen at: www.etenschappelijkedoorbrakendeklasin.nl

Winning topics

The winning topics of the Radboud Science Awards that are described in the books are the following:

Book 1: Fear, Graphene & Thoughts about the Beginning (Peeters, Meijer & Verhoeff, 2011);

Book 2: DNA, Behaviour Control & Infections; (Peeters, Meijer & Verhoeff, 2012);

Book 3: Perception and Movement, Under Influence, Group Pressure & Dangerous Ideas; (Peeters, Meijer & Verhoeff, 2013). Examples of children’s own research questions in Book 1 and Book 3, respectively:

- If you see a spider, and a week later you see it again, will you then be more afraid or less?
- Can you swim better in cold or hot water?

Research

Qualitative research has been conducted on the gains for children and teachers who participated in the projects (Koppens, Peeters & Verhoeff, 2013). The gains for the children were: the academic world became more familiar, and they learned how to ask good questions and get an answer on their questions. Teachers experienced more commitment towards scientists and scientific research after a project, they learned to raise inquiry-based learning to a higher, more academic level in the classroom and how they can implement 21st century skills into their science lessons.

Lessons learnt

- It takes at least two years to implement IBSE projects into schools.
- It is important to make a contract with the school regarding the amount of effort they put into the project, e.g., amount of time for each teacher.
- Teachers need training in how to formulate good research questions and how to design an experiment (as they have mostly not an academic degree).
- Teachers have to adapt to the role of coach and supervisor instead of expert.

Expertise to share with others

- Book series (although written in Dutch for now) and video clips of classroom activities;
- Scientists in the project team can help teachers in various phases of the inquiry process;
- Experiences with what scaffolds work in the classroom for each step of the inquiry process;
- Introducing an honourable prize such as the Radboud Science Awards is a good way of embedding an SEH in the university. It gives the university a podium to show its most important research to a broad audience and creates a lot of publicity. Furthermore, researchers are motivated to win the prize and to work in project teams.

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Peeters, M., Meijer, W., & Verhoeff, R. (Eds.) (2012). *Scientific breakthroughs into the classrooms! Fear, Graphene and Thoughts about the Beginning*. [Wetenschappelijke doorbraken de klas in! Angst, Grafeen en

Denkbeelden over het begin.] Nijmegen: Wetenschapsknooppunt Radboud Universiteit Nijmegen.

Bridging the Gap between Formal Education and Informal Learning via Science Centre Pedagogy

Professor Hannu Salmi
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“Science education is not only a question of advancing technology or of demands for a scientifically qualified workforce, but is also a question of social goals. The aim is not solely to produce more scientists and technologists; it is also to produce a new generation of citizens who are scientifically literate and thus better prepared to function in a world that is increasingly influenced by science and technology.” (Coombs, 1985)

The role of learning in informal contexts is increasing in modern societies. This phenomenon is closely related to the growing impact of science and technology on our everyday lives. Lifelong learning needs new practical forms.

Learning in informal contexts has often been regarded as the opposite of formal education. Even the names of the classic books - *Deschooling Society* (1971) by Ivan Illich and *The Unschooling Mind* by Howard Gardner (1984) have been provocative. However, both authors argued that learning from informal sources was effective and motivating.

The relationship between the different kinds of education is shown in Figure 1, which is a combination from several sources. Originally, it was the scheme for educational statistics in the UNESCO report *Learning to Be – The Faure Report* in 1968.

The main results about informal learning and especially about science centre education are related to the effect of motivations on learning (Salmi 1993, 2011; Falk and Dierking 1992; Subramaniam 2003; Osborne and Dillon 2008; Fenichel and Scheingruber 2010). In the context of science education, attitudes toward

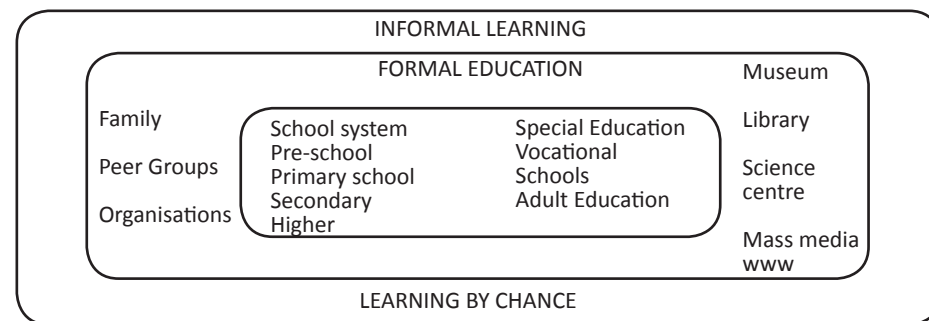


Figure 1

science have been defined as “feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society, or scientists themselves” (Osborne, Simon, and Collins 2003). Influencing attitudes towards science has been said to be the key of educational improvement as well as getting the teachers’ commitment as key players in the process. Because attitudes have been shown to be formed early, being hard to change after basic education, it is important to analyse and influence them before the transition to middle school. Influencing attitudes has been shown to be especially difficult if they have been formed more intuitively, automatically, and on emotional basis rather than more consciously in process of time (Kahneman 2003). However, both age and gender have to be taken into account. It has been noticed that girls already develop more negative attitudes towards science at an early age and that in general pupils often tend to lose their interest in science by time.

In the USA, the background to the expansion of modern science centres in the 1960s was the Sputnik phenomenon. The attitude towards the study and teaching of science dramatically changed. The educational system in the USA was totally reformed. The San Francisco Exploratorium opened in 1968. In the 1970s and 1980s there was a period when nearly identical exhibitions were built. The growth of science centres since the 1990s

in Europe, 2000s in Asia and Latin America, and since 2010s in Africa is closely related to the developments of the information society. The role of learning in informal contexts is increasing in modern societies – meaning the countries which are developing their societies by investing and creating opportunities for research, innovations, and education. The international nature of science and science centres is the platform for this. However, the staff of science centres adapt their national and local features to their own ideas when choosing the content, design, educational and programme ideas.

The objective is to utilise the key elements of curricula in different countries to teach the scientific research process based on learning in science centres and teaching at school. Pedagogical hands-on methods originally developed in science centre context are adopted, converted and moved into the formal education via effective teacher training. The evidence based results in co-operation of University of Helsinki and Heureka Science Centre have produced encouraging results related to open learning environments as well as best practices developed in co-operation with teacher education institutes, school authorities, universities, educational administrations and schools.

A science centre is a learning laboratory in two senses. First of all, it is a place where visitors can learn scientific ideas by themselves using interactive exhibit

units. Secondly, it is a place where informal education can be studied in an open learning environment. The trend in informal science learning is that these science centre experiences can be spread worldwide.

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Renouveau de l'Enseignement des Sciences et de la Technologie au Sénégal¹

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L'Histoire

2003: Plaidoyer de l'ANSTS pour un enseignement de qualité pour répondre aux exigences d'une société de l'Information, du Savoir scientifique, de la Technologie et de l'Innovation.

2004: Création par le MEN du CNPDEST dont la mission était de diagnostiquer et de proposer un Programme Indicatif National.

2004-2007: Etude soutenue par la Wallonie Bruxelles International, la Coopération, Française, l'USAID, etc.

Eléments du Diagnostic de l'EST

Forces :

- éveil scientifique : case des Tout-petits
- Initiation Scientifique et Technologique à l'élémentaire
- démarche d'investigation prescrite

- dans les textes officiels
- Classes Pilotes « la main à la pâte »
- 2 phases d'expérimentation
- Blocs Scientifiques et Technologiques : Mutualisation des ressources

Faiblesses :

- insuffisance de salles spécialisées
- Equipements, ressources et matière d'œuvre
- Formation des maîtres
- tous les prétextes pour ne pas recourir
- à la démarche d'investigation
- nombre de BST (8) insuffisant
- approche pédagogique inadaptée

Entrainant une diminution grave de la motivation envers les sciences et la technologie, non seulement au fil des ans comme le montrent les résultats des épreuves nationales et internationales, mais aussi au fil des années de scolarité (l'enseignement des sciences tue la motivation existante originellement chez les enfants) ;

- approche genre
- évaluation : bachotage (savoir restituer)

Conséquence :

- Désaffection des séries scientifiques et techniques
- En 2008, sur 20 476 bacheliers seuls 4 316 en Sciences et Techniques (21%)

Renouveau proposé :

L'ANSTS et le CNPDEST ont proposé et remis aux Autorités de l'Etat un Programme Indicatif National de Renovation de l'Enseignement des Sciences et de la technologie.

Ce document propose de mener un certain nombre de stratégies parmi lesquelles, celles acceptées par toutes les Académies des Sciences (par F. Robin, RIE 2009)

- « Soon is better » ;
- assurer un enseignement des sciences pour tous ;
- abandonner la pédagogie transmissive qui tue la motivation et les compétences liées à l'esprit scientifique ;
- promouvoir la Pédagogie d'investigation ;
- s'assurer de l'implication des personnalités scientifiques ;
- avoir le soutien de la coopération internationale.

Activités démarrées :

- Formation des formateurs
- Didactique et pédagogie situationnelles
- Conception de ressources pédagogiques
- Elaboration d'un guide méthodologique
- Diffusion du document
- Débat télévisé
- Partenaires

Projets en voie d'élaboration pour une mise en œuvre.

Conclusion :

Grace à son plaidoyer, l'Académie Nationale des Sciences et Techniques du Sénégal a fortement contribué à faire prendre conscience de la nécessité de repenser le système éducatif pour assoir une bonne base de maîtrise de la Science et de la Technologie. Avec un groupe d'experts nationaux et internationaux, elle a proposé un Programme Indicatif de Renovation qui ambitionne de changer les paradigmes de l'Enseignement des Sciences et de la Technologie au Sénégal. De part son approche pédagogique, cette rénovation fait de l'apprenant un acteur principal du processus d'acquisition du savoir, du savoir faire et du savoir être à partir de situations problèmes tirés de son environnement.

¹ Editor's note: This contribution has been adapted from its original poster format. For an English-language translation, please see page 70.

Diagnosis of Science and Technology Education in Senegal

Professor Abdoulaye Samb

Strengths:

- First acquaintance: the case of the young children
- Scientific and technological initiation in primary schools
- Investigation approach prescribed in legal texts
- Pilot classes “*La main à la pâte*”: two experimental phases
- Scientific and technological blocs: mutualised resources

Weaknesses:

- Lack of suitable classrooms, equipment, resources and material
- Insufficient training of teachers
- Many excuses to avoid the investigation approach
- Small number (8) of BST (Blocs Scientifiques et Technologiques)
- Bad pedagogical approach
- Different attitudes of male and female pupils
- Bad assessments that yields cramming

These drawbacks in education yield a severe lack of interest in studies of S&T during the school year but more dangerously throughout the years of schooling. In other words, the current science education system destroys any initial motivation on the side of children.

Result:

Estrangement from scientific and technological studies: in 2008, only 21% of the 20,476 students obtaining a high school diploma got their diploma in S&T.

The proposed renewal

2003: ANSTS pleads for improving the quality of teaching in order to meet the requirements of a society of information, scientific knowledge, technology and innovation.

2004: The Ministry of Education creates the CNPDEST with the mission to put a diagnosis and proposes a National Indicative Programme (PIN) to renew S&T education.

2004-2007: The study is supported by Wallonie Bruxelles International, the French Cooperation, the USAID, among others.

The PIN document proposes a few strategic actions among those recommended by all science academies (cf F. Robin, RIE 2009):

- Teach science to young children (“Sooner is better”);
- Teach science to all;
- Stop frontal pedagogy that kills motivation and scientific skills;
- Promote investigation pedagogy;
- Obtain the support of scientists;
- Be supported by international cooperation.

The launched actions and projects ready to be implemented:

- Training of expert trainers
- Didactics and situational pedagogy
- Design of pedagogical resources
- Writing and dissemination of a methodology guide
- TV debates
- Partnerships

Conclusion:

The National Academy of Science and Technology advocacy has raised the level of awareness about the need to renew the way the education system sets up the bases in sciences and technology. With the help of national and international

experts, it has proposed a renewal indicative programme whose ambition is to shift the paradigm that rules the sciences and technology education in Senegal. This renewed pedagogical approach takes advantage of everyday life and environmental situations to make the learner himself a major actor in the process of improving his knowledge, skills and self-management competencies.

Translated by Odile Macchi



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Crafting a Health Science Education Programme for Primary Schools in Italy

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Introduction

The epidemiological profile of the Italian population, in line with that of many other countries, is characterised by a progressive increase of demographic and health indicators, such as:

- life expectancy at birth;
- average age of the population;
- prevalence of degenerative pathologies and chronic illnesses;
- prevalence of affluent-type pathologies (e.g., obesity, cardiovascular diseases, drug dependence, work-related or accidental injury), which are strongly linked to an unhealthy lifestyle (e.g., overeating or unbalanced diet, sedentary lifestyle, stress, tobacco dependence, consumption of psychoactive substances).

The above mentioned increased lifespan causes the Italian population to become, at the same time, more fragile from a health perspective, due to the growing number of people who require medical attention (e.g., the aged, disabled, chro-

nically ill). Within the framework of national programmes aimed at containing the costs of medical treatments, activities to prevent the onset of diseases resulting from unhealthy lifestyles represent the best strategy for a healthy life in the long run. The promotion of healthy behaviours is generally considered one of the fundamental components of primary prevention. Initiatives aimed at encouraging healthy lifestyles (health education) are currently being carried out at the primary school level as recommendations and guidelines. This approach has proved to be of limited effectiveness since health education initiatives, often carried out on a sporadic basis, are perceived by children as imposed rules, as they are missing the scientific knowledge that is essential to understanding the educational message.

It appeared, therefore, appropriate to promote and begin an educational programme on health sciences targeted to primary school with the objective of creating awareness and knowledge, at an elementary level, of the structural and functional organisation of the body. The project appears to be a necessary prerequisite to health education programmes and will allow children to acquire, at an early age, correct and healthy lifestyles.

Compulsory school at the primary level represents a unique opportunity for addressing a large audience of students in their initial educational programme. In addition, it is well known that the funda-

mentals of knowledge are established at a very early age.

In this context – with the financial support of Fondazione Roma Terzo Settore for the first year and of the InterAcademyPanel (IAP) and the InterAcademyMedicalPanel (IAMP) for the second year – a five-year project entitled “Assessment of Feasibility for a Health Education Program in Compulsory Primary School”, aimed at developing an IBSE-based health science education programme at the primary school level has been developed by a multidisciplinary group (SCIESA group) composed of: a morphologist and project coordinator (M.S.), a biologist and elementary school teacher (B.M.), an epidemiologist (A.C.), a child neuropsychiatrist (F.C.), a cell physiologist (G.S.), an expert in science education in primary school (S.C.).

General Outline of the Teaching Programme

First phase: learning to read the book of nature; structural and functional organisation of the human body. This phase of the programme, aimed at first and second year primary school children, is designed to let them become aware of the essentials of structural and functional organisation of the human body through “direct observation” (perceptible anatomy). Teachers have to take into account personal experiences and intuitive ideas to promote discussion and cooperative work with children. In this first year, and in the following ones as well, the teaching medi-

ation will be aimed to support processes of reflection and social re-elaboration of knowledge.

Second phase: learning through an experimental approach the fundamentals of functional anatomy. During this phase (third and fourth grade), topics previously treated will be further developed. Additional awareness and knowledge will be added through the implementation of simple “hands on” experiments, as well as by sharing with them simple but relevant results of the scientific research. Teaching methods for meaningful learning are going to be enriched with a variety of teaching aids and strategies such as audio-visual media, drama, etc.

Third phase: knowing the risk factors and countering them. The third phase of the programme (5th grade) is expected to conclude the course by moving from health sciences to health education. A scientifically correct knowledge of risk factors and unhealthy behaviours, aimed at improving personal well-being, is generally regarded as a fundamental condition for the active defence of health and a necessary component of all initiatives for primary prevention.

Methodology

Specifically, the pedagogical approach will be based on two fundamental, basic strategies: inductive methodology and interactive teaching. These involve:

- active participation and involvement of students during the educational process;
- the use of evidence-based science education strategies;
- a didactic approach based on students' daily experiences, rather than on conventional teaching methods;
- the collaboration with the children's families during all of the programme activities;
- a very early start of teaching (first year of the cycle), in order to encourage as soon as possible the interest of the students towards the environment, the functioning of the body-mind system and to expand their knowledge in favour of well-being and health.

Preliminary Results

Primary school in Italy is for the duration of five years and begins when children are six years old. Four "first grade" classes from two schools afferent to the *Istituto Comprensivo L. Settembrini*, via Sebènico, Rome (on the whole, 78 six-year-old children and 8 teachers), were engaged in the project. Teaching activities started in September 2013.

Three teaching modules have been used:

- First module: "Us and the Environment" (the relationship between the child and the physical and social environment in which he/she lives).
- Second module: "The human body and the movement" (i.e. the mo-

vement in relation with the musculoskeletal system and the general conformation of the human body).

- Third module: "Relationships and bodily exchanges between the individual and the environment" (what goes in and what comes out). The module is divided into two sections, dealing with "the journey of the air" (respiratory tract) and "the journey of food and beverages" (digestive tract), respectively.

Production of teaching support materials

A specific evidence-based programme, developed for each module, has been discussed with the teachers. Appropriate teaching aids (tool kits) produced by the SCIESA group have been provided to the teachers.

Training of the teachers

The eight teachers involved in the project participated in a preliminary two-day training programme aimed at improving their abilities in evidence-based teaching; monthly meetings with members of the SCIESA group were focussed on the evaluation of the work done, the revision of the designed teaching units and the operational aspects of the inductive method. Additional training has been programmed at the beginning of the second year of the project.

Evaluation of results obtained

The first year of the project was comple-

ted in late June 2014. The evaluation of the results, based on records that teachers have taken on a "day-by-day diary" and on "self-evaluation sheets" prepared for each teaching module, is in progress. Class activities aimed to assess the ability of children to ask questions, to argue and to provide evidence of what they say, will also be planned. The involvement of the pupils' parents will be considered through specific questionnaires.

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Science Education: A Key Activity of Academies of Sciences, including the IAS

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Science Education: Why?

Science education is currently viewed as inadequate in both the developing and developed worlds. This renders the need to promote science education at schools throughout the world imperative, particularly in developing countries, so that children nurture their quantitative acumen, become more inquisitive and analytical, innovate and ultimately be better qualified to address development problems and convert accumulated knowledge into products and services of monetary value, i. e. create wealth.

Science Education: A Worldwide Interest of Academies of Sciences

The French academician Pierre Léna (2004) cited some of the ideas proposed at the 2000 Budapest World Conference on Science which underline the importance of education in science as a fundamental need of modern societies to achieve peace, justice and a sustainable development. It was Léna who together with Charpak (d. 2010) and Quéré, under the auspices of the Academy of Sciences of France (ASF), launched the famous science education initiative called *La*

main à la pâte (the hands-on or the hand in the paste), which eventually became a model for the involvement of Academies of sciences in science education of children at the world level (Descamps-Latscha 2003).

In the US, the National Academy of Sciences (NAS) played a major role in developing the National Science Education Standards, which were designed to make scientific literacy a reality in the US in the 21st century (Alberts 1995). A further turning point in the narrative of science education and science in general came with the Academy's 2007 publication of its famous report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (COSEUP 2007). This publication addressed the S&T future of America, specifically in the context of science education, and presented four basic recommendations which are encapsulated in catchy phrases and focus on actions in K–12 education (*10,000 Teachers, 10 Million Minds*), research (*Sowing the Seeds*), higher education (*Best and Brightest*), and economic policy (*Incentives for Innovation*) (NAP 2010).

Science education curriculum development has been an area that the political leadership in many countries has rightly considered to be important. Cherry (1996) described how (former) South African President Mandela challenged the country's Academy of Sciences to in-

spire the country's youth to seek careers in science, engineering, and technology. Some African Organisation of Islamic Cooperation (OIC) Academies such as the Ugandan National Academy of Sciences (UNAS) view science education as the single most important activity in which an Academy of sciences can be involved (Mugambi 2006). Some Asian OIC Academies of sciences are active in the domain of science education, such as the Academy of Sciences Malaysia (ASM) (Ong and Abdul Rahman 2002).

Nevertheless, the interest shown in promoting science education by the Academies of sciences in OIC countries does not match that of the world's leading Academies of sciences. This is disappointing as implementing activities in science education is not normally a costly endeavour.

Some IAS Activities in the Domain of Science Education

The IAS had realised that an inextricable link exists between the well-being of science and the culture thereof in society and activities in the domain of the history of science. Thus, it has paid attention to cultivating a culture of science within OIC societies by organising a series of conferences – with decision-makers particularly in mind – on the subject, including its 1991 Amman Conference on “Science and Technology Manpower Development”. In 1999, it organised a conference on “Science and Technology Education for Development” in Tehran (Iran) which

analysed many aspects related to the promotion of science education at all levels.

To encourage the younger generations of today to develop a sense of appreciation of, and delve into the scientific enterprise with confidence, the IAS published a number of journals and books that depicted the outstanding scientific achievements and portrayed some of the towering scientists of the golden age of Islamic science, as well as postcards carrying the portraits and a brief narrative of such personalities.

The IAS also organised a number of specialised seminars and symposia with the help and support of other science academies as a well as ISTIC on themes emanating from the UNESCO History of Islamic Science, Engineering and Technology (HISSET) Programme. The IAS subsequently helped in the convening of similar symposia in Malaysia, Russia, and Qatar.

Moreover, by honouring scientific achievement and identifying champions of science, the IAS has cultivated public interest in the scientific enterprise in the Islamic world. In line with this objective, young researchers in the fields of science have been honoured and their achievements publicised through a number of awards that the IAS has instituted.

Science Education and IBSE in Jordan

Today, Jordan boasts one of the highest adult literacy rates in the Arab world,

around 99% (UNESCO, 2014). With a population of over 6 million, it is among the region's highest spenders on education, investing more than 20.4% of its GDP on education, and boasts over 30 state and private universities. It leads in the region in terms of the number of researchers, and according to the Global Innovation Index 2014, Jordan is the fifth-most innovative economy in the Middle East, behind the United Arab Emirates, Saudi Arabia, Qatar, and Bahrain (GII, 2014).

Jordan has managed to undertake important reforms in the field of education over the last three decades in many areas.

However, research carried out in 2010 to study "Science Teachers' Perception of Educational Reform of Science Teaching in Jordan" revealed that there are a number of difficulties hindering progress in science education. These include the fact that teachers do not play a part in the reform or implementation processes and have to adhere to approved textbooks for their material. Moreover, teachers appear to suffer from the lack of appropriate in-service training (Qablan et al, 2010). These are problems that seem to be common in other developing countries.

Conclusion

A multifold challenge remains to be addressed by the science education community, including academies of sciences. Firstly, there is the question of capacity building, i.e. how do we get teachers

trained and qualified to deliver science/science education in a clear, concise and exciting manner and, indeed, with the required enthusiasm? Another important challenge that must be addressed by developing countries is the language in which science subjects should be taught. Should it be the local language or a more universal or "world" language? This of course gives rise to the question of the availability of books, teaching material, etc, in local languages.

Secondly, how do we assess the impact of our science education strategies quantitatively and how do we measure the impact of science education on students and societies?

Thirdly, when do we move as we should from Inquiry-Based Science Education (IBSE) to Inquiry-Based Education (IBE)? This seems to me to be a real practical problem. For how can we ask or expect young children who have, for example, just enjoyed a non-conformist IBSE class to switch back to a traditional mode of learning in a subsequent history or language lesson, for example? Shouldn't we start thinking of turning most of our education into IBE??

Lastly, Academies of sciences can play a critical role in science education worldwide by sharing experiences and promoting best practices.

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International Collaborations¹

Assessing the Outcomes of Inquiry-Based Science Learning

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In the past few decades, IBSE has become one of the most prominent alternatives to traditional science education. Its popularity generated a variety of implementations in terms of interpretation of inquiry, depth of changes compared to traditional teaching, areas of application, complexity of inquiries, and length or frequency of the application of the relevant activities. The European Union's FP7 has supported around 20 projects aiming at improving the quality of science education, most of them focussing on inquiry learning. These projects resulted in new methods, rich experiences and a variety of good practices, and a number of teachers received training in inquiry-based teaching.

In the last period, assessment has come to the forefront of research and development, especially formative assessment taking place during the teaching-learning

process acknowledging the importance of feedback in student's learning. Strategies for Assessment of Inquiry Learning in Science (SAILS) is an FP7 project aiming at supporting teachers in mastering the skills necessary to provide students with adequate feedback during inquiry learning activities. The SAILS project covers secondary level science education (for students aged 12-18 years) and utilises existing materials, results of previous IBSE projects and materials developed by the participating research groups and practitioners.

The project has two main innovative components, as it aims to (1) identify the expected outcomes of inquiry-based learning and (2) implement a variety of forms of assessment in the classroom processes. This paper focusses on the first issue: defining and operationalising cognitive outcomes of inquiry-based methods, as this has important consequences for the evidence-based implementation of IBSE as well.

The need for introducing measurements into research on science education may be best illustrated by a citation from Kelvin: "If you can not measure it, you can not improve it". For comparing the impact of the different implementations of inquiry methods, their outcomes need to be measured. Similarly, for identifying those classroom activities that are the most beneficial, a causal relationship must be established between these inquiry activities

¹ The following section encompasses a selection of the information presented at the Conference during numerous oral presentation and poster presentation sessions attended by the participants. When possible, graphical data from the original presentations have been included.

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and their effects on the development of students' knowledge and skills. The particular difficulty in this case is that those general outcomes of inquiry-based learning that are often enumerated among the goals of IBSE are ill-defined and not immediately observable. Thus, as an inevitable step to use the scientific methods in research on IBSE, the expected outcomes should be more precisely defined, operationalised and made measurable, following the suggestion of Galileo: "Measure what is measurable, and make measurable what is not so." Similarly to measurement, as in has a prominent role in the advancement of sciences, feedback has an extraordinary position in developing working methods, including efficient methods of teaching and learning.

For identifying and defining the desirable outcomes of inquiry learning, in other words, defining what to assess, a deeper understanding of the underlying human mental processes is required. For this understanding, a number of theoretical and conceptual resources may be used which could also be the foundations of framework development. These resources include theories of cognition, cognitive development, research on learning and instruction, curriculum development, standards and standard setting. Based on this background, four main dimensions of outcomes of inquiry learning were identified.

The first dimension deals with inquiry skills, as their development is the im-

mediate aim of IBSE. These skills, such as identifying problems, designing and conducting experiments, collecting data, organising, analysing, questioning, planning, implementing, concluding, reporting and applying are practiced during teaching and learning (Wenning, 2007). These outcomes are directly associated with IBSE, but science education has more general aims as well. Through inquiry activities students are expected to be able to better transfer their science knowledge to other contexts and domains and to become more capable problem solvers beyond the particular fields of science as well. These general goals and the related outcomes form the remaining three dimensions. A similar three-dimensional framework was developed for the diagnostic assessment of science with results generalisable and utilisable in the context of IBSE as well (see Csapó, 2012, Csapó & Szabó, 2012).

The second dimension deals with the disciplinary content knowledge. Students being engaged in inquiry activities are expected to better understand and master the learning materials. The outcomes identified in this dimension deal with comprehending the "big ideas" of science, the depth of conceptual understanding, concept development and conceptual change, reduction of misconceptions, learning progression at the given fields of sciences. These are the main goals also associated with traditional science education, but for assessing the efficiency of

IBSE these outcomes should also be taken into account.

A third dimension is the application of scientific knowledge (scientific literacy). This is the focus of the PISA assessments, as they measure how well students are able to apply their knowledge in contexts and situations that are beyond the usual school settings learning (see e.g. OECD, 2013).

The fourth dimension deals with students' cognitive skills, as one of the declared goals of science education is to develop students thinking, and this goal is also frequently mentioned related to IBSE. Three groups of thinking skills may be considered in this dimension, operational reasoning (e.g. control of variables, seriation, class inclusion, classification, combinatorial reasoning, operation of binary logic, probabilistic reasoning, relational reasoning, proportional reasoning), higher order thinking skills (e.g. problem solving, divergent/creative thinking, critical thinking) and scientific reasoning (e.g. hypothesis generation and hypothesis testing).

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The PAN-African Network of Science Centres (PANS)

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The Library of Alexandria has been building on its expertise in the field of informal science education to create a Pan-African Network of Science Centres (PANS). The Library has approached many partners to establish this network and offers to host its secretariat office on the Library premises in Alexandria, Egypt.

As we are moving into the 21st century, the field of education is undergoing an unprecedented transformation. The world which today's children are exposed to is highly networked, technologically sophisticated and is characterised by rapid change and complexity. Citizens of the new century need to be flexible, agile and creative thinkers capable of working in groups, synthesising large quantities of information and applying technology in all aspects of life.

Well-educated citizens are those who continue to learn and are able to inform the public discourse and bridge the distances, whether geographic, cultural or linguistic. A formal educational context is not enough to keep up with an ever-expanding rate of knowledge production. A whole environment in which the concept of life-long learning is practised is crucial in order to empower new generations

with the necessary tools to deal with the new global perspective.

The Library of Alexandria has been a leader in informal-science education in Egypt and the Middle East and North Africa (MENA) region. We collaborate with governmental structures, NGOs and the private sector to establish an environment where the general public, especially school children, acquire a passion for knowledge. Collaborations on the national, regional and international levels have been established to foster expertise and exchange know-how in the field of informal science communication.

The Library is building on the experience gained in launching the North Africa and Middle East Network of Science Centres (NAMES), which the Library launched in 2006 in Tunis with four founding members, soon followed by a fifth founding member: BA Planetarium Science Center, Egypt; The Scientific Center of Kuwait, Kuwait; Tunis Science City, Tunisia; Turkey Science Centers Foundation, Turkey; Sultan Ibn Abdul-Aziz Science and Technology Center (SciTech), Kingdom of Saudi Arabia. Currently, NAMES has 13 full members and one sustaining member. The Library is hosting the secretariat office of the NAMES network.

The Library of Alexandria has been building on its expertise in the field of informal science education to create a Pan African Network of Science Centres (PANS). The

Library has approached many partners to establish this network and offers to host its secretariat office on the Library premises in Alexandria, Egypt. Egypt, being at the north tip of the African continent, is in a very good geographical position to bring institutions, universities, science academies and NGOs from all over the world to establish PANS.

The goal is to build science and technology capacities in African nations by establishing informal hands-on science communication centres and strengthening work capacities through networking, knowing each other, communicating, sharing tools, and running common projects.

Africa, being the second largest continent in area and in population, and hosting 54 countries who are members of the African union (excluding Morocco), definitely deserves us all working together for a better future for its young generations. A future that is one of choice, not chance.

The Pan-African Network of Science Centres (PANS) will have the mission of building science and technology capacities in African nations by establishing informal hands-on science communication centres. As stated in the Inter Academy Council report of 2004 entitled *Inventing a better future*, "Local S&T capacity is essential for using and contributing to the world's valuable store of knowledge. Leaving the scientific and technological breakthroughs to the highly industria-

lised nations and expecting the rest of the world to benefit from the results is an illusory and unproductive policy".

The Objectives of the PANS network

- Strengthening work capacities through networking: knowing each other; communicating; sharing tools; and running common projects.
- Enhancing professionalism of moderators and animators in the informal education sector.
- Improving science communication in mass media.
- Stimulating the establishment of public policies in the field of science popularisation.
- Encouraging the creation of science centres in African countries to complement formal science education in schools and universities.
- Giving support to the members to enable them to secure funding.

Potential Members of PANS

- African Academy of Sciences, Kenya
- Bibliotheca Alexandrina, Egypt
- Fondation Sigma, Morocco
- Association Nature et Patrimoine, Morocco
- Science City, Tunis
- Club Scientifique de Setif, Algeria
- Milset Africa, Lybia
- University of Bangui, Central Africa

- Art-Consult Development, Burkina Faso
- Les Jeunes Chercheurs Associés pour le Développement (JCAD), Cameroon
- Association Forum des Jeunes pour la Promotion du Développement (FO-JEPDE), Cameroon
- Collectif des Organisations de Promotion de la Culture Scientifique et Technique, Cameroon
- Association Karamba Touré (AKT), Mali
- Association la Jeune Société du Savoir (JSS), Mali
- Compagnie théâtrale Kàddu Yaraax, Senegal

Supporting Institutions

- TWAS
- International Planetarium Society
- African Academy of Sciences
- Southern African Association of Science and Technology centres (SAASTEC)
- Institut de Recherche de Développement (IRD)

Progress so far

The Library of Alexandria has already created a collective map of what is taking place in Africa concerning the promotion of science and scientific culture and has identified potential partners. To promote the initiative the Library has created PANS website and hosted it on its server.

The Library will organise a meeting to launch the network for all concerned partners and potential members. The Library is seeking sponsors for the event which it will host in the near future.

The Union for the Mediterranean (UfM)

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UfM Secretariat: an organisation promoting regional cooperation in the Mediterranean

- An organisation gathering the 43 countries of the Mediterranean.
- A project-based approach: Implementation of concrete regional projects and initiatives by following the principles of co-ownership and variable geometry.
- A platform for partnerships and synergies with governments, key stakeholders and International Financial Institutions.
- A focus on Economic & Social Development, Energy, Environment & Water, Transport & Urban Development and Higher Education & Research.

Higher Education and Research Projects

The UfM Higher Education & Research projects aim to:

- Ensure an equitable access to education and vocational training.
- Facilitate transnational mobility for students, academics and researchers.
- Encourage the development of high-standard joint study and research programmes through the

reinforcement of quality assurance, accreditation and recognition procedures.

- Boost innovation, knowledge & technology sharing and its return on the industry.
- Align teaching and learning with the labor market demands and increase students employability.

Three labelled projects:

1) Euro-Mediterranean University of Fez (UEMF)

The UEMF will stand as a unique central platform to promote dialogue, cultural exchange and cooperation between both rims of the Mediterranean. The regional dimension will be achieved by:

- A high-standard of education and research programmes with important impact on the development of the region.
- Highly qualified professors and students from Europe, the Mediterranean area and Africa.

2) Euro-Mediterranean Master & PhD programmes

These programmes, promoted by the EMUNI University, will focus on priority topics for the transformation of the Euro-Mediterranean region and will envisage training committed and highly competent students by contributing to their mobility and employability.

3) Higher Education on Food Security and Rural Development

This project combines allocating fellowships for Southern and Eastern Mediterranean students by implementing five specific actions aimed at improving the ongoing CIHEAM MSc degrees and advanced training courses for professionals.

- Foster entrepreneurship, employability and gender issues
- Create a Mediterranean Doctoral Platform
- Develop e-learning
- Enhance Quality Assurance Systems
- Strengthen degree recognition and internationalization of MSc degrees

Regional challenges call for regional solutions: UfM label added-value

- Strong political commitment: unanimous approval of 43 UfM countries
- Support in complex regional projects: mobilisation of governments and main stakeholders in the region
- Access to finance: wide network of public and private donors and International Financial Institutions
- Assistance in communication and promotion: increased project awareness and visibility



■ Membres de l'UPM

▨ Pays observateur

Science Education and the Network of African Science Academies (NASAC)

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NASAC is an affiliate network of IAP for Africa, and runs Science Education Programme (SEP) as one of the flagship programmes. NASAC was founded in December 2001 as an independent forum for African science academies with the aim of providing authoritative science advice for policy formulation toward economic, social and cultural development in Africa. To date, NASAC membership has grown to 19 members from the initial 8. The member-academies are drawn from Benin, Cameroon, Ethiopia, Ghana, Kenya, Mauritius, Morocco, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia and Zimbabwe.

The Governance structure of NASAC is comprised of the General Assembly, which is the highest decision-making body, to which the Board and standing committee reports. NASAC's secretariat is based in Nairobi, Kenya and has operated an international non-governmental organisation since 2012. The activities of NASAC revolve around 4 main objectives: (i) Facilitating the establishment of science academies in countries where none exist; (ii) Strengthening existing academies; (iii) Serving as the voice of science in the continent; and (iv) Providing an

independent platform for credible advice on pertinent issues in Africa.

Since 2007, NASAC has viewed IBSE as a preferable approach for teaching and learning science because it uses key pedagogical features that can be implemented in various ways using localised materials. On this merit alone, the science being taught in schools, especially primary schools, can be both practical and relevant for the students and encourage their retention in scientific careers thereafter. To further this view, NASAC Board appointed the SEP Focal Points, a group consisting of experts in science education and/or individuals involved in science education curriculum development in their respective countries. The Chair of the SEP Focal Points is currently Prof. Elly Sabiiti from Uganda, while the Vice-Chair is Prof. Ahmadou Wague from Senegal. Prof. Gilford Hapanyengwi from Zimbabwe serves as the Secretary. The members of the SEP Focal Points have a tenure of three years and aspire to have all NASAC Academies represented in the Group.

Some of the major activities carried out by NASAC since the inception of the programme, and mainly with funding from IAP, include: endorsement by member Academies of IBSE as the best method for teaching and learning science in primary schools, and especially for girls; conducting a baseline survey on the status of IBSE in Africa; initiating IBSE pilot schools in Uganda and Cameroon; and fostering

the use of ICT and locally available materials for IBSE in schools. In addition to this, NASAC involves policymakers, mainly from the Ministries of Education, Science, Research and Technology in attempts to influence educational curricula for science. With the limited resources available for SEP activities, the Focal Points prioritised: (i) conducting a baseline survey on the status of IBSE in countries with NASAC members; (ii) the visiting of schools by scientists and holding discussions with local teachers; and (iii) reviewing the training-of-trainers activities to enhance the ripple effect of localised IBSE. The members also committed to embarking on electronic communication for their own deliberations on the foregoing priorities.

From the various activities undertaken so far, the SEP Focal Points in the course of their work mainly recommended that:

- Mobility challenges for scientists in respect to immigration and visa acquisition which inhibits networking/interaction among science-education experts and participation to SEP events should be overcome. This could either be done by setting elaborate notices for SEP activities, or having the local academy liaise directly with their immigration department.
- In order to prioritise SEP activities in-country and in-sync with other NASAC members so as to have a regional approach in tackling cur-

riculum and accreditation issues in science education in the continent, it was important that institutional arrangements be devised that will ensure commitment to implementation of IBSE in African schools at primary level of education.

- The IBSE survey information, once collected and analysed, will help in making specific and relevant recommendations for NASAC members' in-country situation in respect to science education.
- The role of policymakers in formulating sound curriculum content and teaching methodology for science within schools in Africa should not be underestimated. This is particularly critical in instances where science and education fall in different ministerial portfolios within government.
- The value-addition of scientist-teacher interaction in making SEP relevant to learners and retaining the students in science and science-related careers is equally critical. This stems from the premise that the best scientists are not usually the best teachers, while the best teachers are not necessarily the best scientists. The interphase of science methodology and pedagogy ought to be pursued when teaching or learning science.

NASAC endeavours to remain both vibrant and relevant in science education in the continent mainly through capitalising on activities that can be undertaken with reduced funding, but yet have a global/regional focus for country-specific educational priorities. Curriculum enhancement for relevance and contextual application of science has been proposed. Ways of developing a standardised accreditation or evaluation system across Africa have been discussed, especially in pursuance of economic integration among regions. The use of ICT as a tool that can ease reliance of external funding and enable NASAC to continue supporting core-SEP activities has also been seen as way for encouraging training-of-trainers initiatives as well as scientist-teacher interactions.

Being a consortium of merit-based Science Academies in Africa and currently constituting of 19 members, NASAC aims to obtain concrete case studies for IBSE considerations in science curricula. For science academies in Africa, it is critical to sustain a continuous supply of scientists throughout the education system. IBSE and continuous teacher professional development promises to spur sustained interest in science and scientific careers by students in Africa. The partnership between NASAC and national policymakers (through national academies) is important for encouraging inclusion of IBSE in in-service training for teachers and developing an evaluation system that

will encourage science students to pursue scientific careers in Africa. The partnership between NASAC and IAP is critical in getting the results of the baseline survey published and widely disseminated.

**International Cooperation as a Key Pillar
in IBSE Implementation Strategies
The Case of Mexico**

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Abstract

Innovation in Science Education (INNOVEC) is a non-profit Mexican organisation that has promoted the implementation of Inquiry Based Science Education (IBSE) nationwide in order to contribute to the development of scientific attitudes and abilities in basic education students in public schools. INNOVEC was created as a spin of the United States-Mexico Foundation for Science (FUMEC), with a Board led by business and academic leaders as part of the binational collaboration.

International cooperation has been one of the core strategies at INNOVEC. This exchange has resulted in the enhancement of IBSE models, teaching methodologies and educational materials. Thanks to the support and advice of different countries that had promoted IBSE internationally, INNOVEC has developed a model that has enabled the scaling of the IBSE programme to reach more than 400 thousand students of basic education in the country.

There have been different stages in building international cooperation.

A long-term partnership between the NSRC (National Science Education Center, now Smithsonian Science Education Center) of the United States and INNOVEC was crucial for starting the programme in Mexico, as there was no previous experience in working with IBSE in our country. This collaboration started with strong support of the U.S. National Academies and FUMEC. The NSRC provided high quality inquiry based science curriculum and teaching materials, authorising their use in Mexico, including their translation and adaptation to the Mexican context. NSRC also facilitated the adoption of their systemic model which includes five critical components: professional development, curriculum, material support, assessment and community support.

In search of new alliances to strengthen the programme, Mexico organised the first International Conference on IBSE in 2001, in which science academies, ministries of education, universities, researchers and specialists from different countries participated. This allowed us to participate in an international network that has maintained an ongoing collaboration for more than a decade. To date, Mexico has organised seven International Conferences taking place every two years since 2001.

International Conferences as well as INNOVEC's participation in other international forums on IBSE have provided valuable opportunities to discuss educational trends, teacher training, technology implementation, assessment, evaluation, education policy and other key issues that have proved to be fundamental to improve the Mexican programme.

Today, international cooperation remains a central strategy to INNOVEC. There is now a broad partnership with IBSE programmes in other countries and international institutions, which has allowed Mexico to enrich and strengthen the programme components.

The professional development of teachers has been a central theme for INNOVEC. Exchange with teachers and specialists involved with IBSE programmes in other countries has been very rewarding for this purpose. This exchange has been mainly with teachers from the USA, France, Chile, and Colombia, who have supported the development of workshops and qualification courses for leading teams responsible for teacher training and monitoring IBSE programmes in the states.

Mexico has also supported other countries such as Panama and Chile in the training of teachers and team leaders in charge of IBSE programmes in their regions. It has also contributed with the IAP Science Education Programme to generate documents and organise conferences and

seminars to discuss and establish guidelines for the IBSE programme worldwide. INNOVEC has developed its programme taking into account most of these guidelines (Report of the Working Group on International Collaboration in the Evaluation of "IBSE Programmes" and Principles and Big Ideas of Science Education).

Another main issue for INNOVEC has been the development of materials and tools that enables teachers and teacher trainers to strengthen their skills in the IBSE programme. Therefore, Mexico has made the international version of two DVDs and one thick book developed by the French LAMAP programme, which have been used in Mexico and other countries too (DVDs: "Learning Science and Technology in School", "Learning Science and Technology in Secondary School"; Book: "29 Key Notions to Savor and Enjoy the Science Concepts").

In addition to partnerships with academic institutions and other IBSE programmes of the world, INNOVEC works with international companies that contribute to improving the scientific training of children and youth. Such is the case of the collaboration with Siemens Stiftung which developed a programme called Experiment that will be adapted in order to be implemented in Mexican schools. INNOVEC is also providing advice and support to TAMSA A.C. to make the AfterSchool programme they run in Mexico and other countries an inquiry-based programme.

Largely due to international cooperation and with the broad support from Mexican Ministry of Education and the Mexican States Governments, INNOVEC currently operates the IBSE programme in 11 states, where more than 400,000 students and 10,000 teachers of preschool, elementary and middle school levels participate every year. With the support of Mexican and international institutions, INNOVEC has consolidated a network of IBSE teachers to support professional development, monitor the programme, gradually implement an assessment and evaluation methodology, and plan the development of new science teaching modules.

In pursuit of the advancement of the programme, Mexico will continue generating new alliances at the international level to develop and strengthen areas like new assessment models, the use of information technologies for the professional development of teachers, and the science teaching in special education, among others.



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The European Fibonacci Project: Lessons Learned from International Collaborations

Professor Petra Skiebe-Corrette
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Fibonacci (2010-2013) was a programme funded by the European Union under the 7th Framework Programme with the aim of disseminating inquiry-based science and mathematics education (IBSME) in Europe (<http://www.fibonacci-project.eu/>).

Fibonacci was preceded by two other programmes funded by the European Union: SciencEduc and Pollen. Within SciencEduc (2004-2006, 5 partner countries, 2 associated partners) methods of IBSE in primary schools were disseminated through a European summer school, 14 national conferences and an online collaborative project. SciencEduc was followed by Pollen (2006-2009, 12 partners, 4 observing countries), in which IBSE was implemented in 10 primary schools in each of the 12 partner countries. Both programmes laid the groundwork for Fibonacci by developing a shared vision of IBSE and by providing the core group.

Within Fibonacci, IBSE was extended to also include inquiry-based mathematics education (IBME). Fibonacci was a dissemination programme. Five different dissemination methods were used:

1. The scientific committee (Michèle Arti-

gue, Peter Baptiste, Justin Dillon, Wynne Harlen, David Jasmin, Pierre Léna): the scientific committee secured the quality of the pedagogical approach and supported the partners by writing three background booklets ("Learning through Inquiry", "Inquiry in Science Education", "Inquiry in Mathematics Education"), which can be downloaded from the Fibonacci website.

2. Three conferences: the conferences included an opening conference (Bayreuth, Germany 2010), during which public awareness was raised and old and new partners were able to get to know each other, a dissemination conference (Leicester, Great Britain, 2012) and a final conference (Trnava, Slovakia, 2012).

3. Field visits: in order to improve the transfer of knowledge between countries and to give an overview about the different ways IBSME can be implemented, seven field visits were held between September 2010 and April 2011 (University College South Denmark, University of Augsburg, University of Ljubljana, University of Bayreuth, University of Amsterdam (Amstel Institute), Graduate School of Engineering of Saint-Etienne (La Rotonde), University of Klagenfurt). Each of the participating countries was able to visit three of these seven field sites. During these field visits it was possible to directly observe the science and mathematics programmes, a component that should be implemented in follow-up programmes.

4. Training sessions and cross-cutting topics: in order to enhance exchange between the countries, five different groups worked on the following topics and created booklets: “Tools for Enhancing Inquiry in Science Education”; “Implementing Inquiry in Mathematics Education”; “Setting Up, Developing and Expanding a Center for Science and/or Mathematics Education”; “Integrating Science Inquiry across the Curriculum”; and “Implementing Inquiry beyond the School”. All of these resources can be downloaded from the Fibonacci website. In addition, each of those groups offered a training session held between September 2011 and March 2012.

5. Twinning: the most important dissemination tool within Fibonacci was the twinning between countries. 12 twinning pairs between 24 partners (universities, teacher training centers, research institutions, etc.) were formed. These twinings were between a reference centre and a twin centre “1”. In addition, twinings were made between a reference centre and a twin centre “2”, the difference being that a twin centre 2 was not as experienced as a twin centre 1, and the twin centre 2 was an associated partner and not a full partner. The reference centres were the most experienced institutions. These pairs developed or shared expertise (1) in continuous professional development (CPD), (2) in setting up or expanding a centre for science or mathematics educa-

tion and in (3) teaching materials.

The Evaluation of Fibonacci was done by Magda Kirsch and Yves Beernaert (Educonsult). Their evaluation showed that twinning can be a method for transferring knowledge and experience between different countries if certain criteria are met.

Criteria for successful cooperation

- Similar visions of IBSE and how it can be implemented
- Similar national or regional contexts
- Knowledge of strengths, interests, needs, expectations of the partners
- Clear focus on training, material support, curriculum, community involvement, evaluation
- Agreement on joint activities with deadlines
- Clear and regular communication
- Joint evaluation of cooperation activities

All in all, Fibonacci has proven to be an excellent method for transferring knowledge and experience between different countries and thus can serve as a model for cooperation between countries that want to improve their science education.

Concluding Remarks and the Future of AEMASE

The last session of the Conference was dedicated to identifying the outcomes of the Conference and discussing its future.

Those attending, who included both Organising Committee members and Conference participants, unanimously agreed that the Conference was a great success, mainly due to the active engagement of people who share a sense of goodwill and initiative for the development of science education for youth around the world. In particular, the Conference successfully brought together Academies and institutions from nations around the Mediterranean rim that have enjoyed a great historic tradition of fostering human civilisation, culture and philosophy. Through this Conference, they were able to exchange ideas on science in relation to education. The role of science and education will be a vital theme in the coming years, as it is closely connected to a wide range of issues including poverty eradication, health education, climate change and, most importantly, peace throughout the world.

One of the most important elements for the success of the Conference was the successful exchange of shared experiences among the participants, who came from more than 30 countries around the world. The participants contributed greatly to the success of the Conference by engaging in it actively instead of simply standing by as listeners. The richness of this dialogue should be preserved in fu-

ture Conferences in order to maintain a tradition of diversity and exchange.

A partial drawback of the Conference was the relative absence of a strong participation on the side of science teachers. The contribution that science teachers could bring to the Conference is of outmost significance and should be considered a priority when organising future Conferences.

The participants of the concluding session generally agreed that the Conference should ideally be held annually or biennially. Moreover, the Academies and other institutions which organise future Conferences should alternate. In other words, the composition of the Organising Committee should vary according to the frequency of the Conferences. Here, the participants underlined the fact that three institutions from Africa (Sudan, Egypt and Senegal) have already offered to organise the next Conference.

It was evident from this discussion that future developments of AEMASE should involve the nomination of a board of 10-12 members who will be responsible for creating a strategic plan with a broad view and a long-term horizon. This board (which should include a member from the world of education) will appoint a secretariat or an Executive Committee responsible for the organisation of the next Conference. The board will also be responsible for managing proposals to a-

chieve funding and for choosing the topics to be discussed at future Conferences.

Furthermore, the meaning of the name AEMASE could be extended to the following concept: African European Mediterranean Academies for Science in Education and not only for Science Education, since it became clear during this Conference that Science plays an important and overarching role in Education in general.

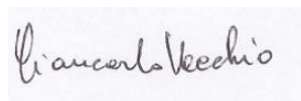
One of the most important ideas which emerged from the Conference was that of realising various partnerships that have been proposed by several Academies and would focus on other subjects beyond IBSE that are connected with Science Education. A very important potential topic for a future Conference could be based on the outcomes of such partnerships.

The Conference officially concluded with an expression of appreciation for the work accomplished by the organisers and for the generous support provided by the Conference co-sponsors. Special gratitude is directed towards the Accademia dei Lincei staff, who greatly contributed to the success of the Conference. Lastly, the Organising Committee offers its sincere thanks to all the participants of the Conference. With their energy and motivation, the first AEMASE Conference proved to be a truly illuminating, productive and enjoyable experience. Its organisers look forward to future Conferences,

which will continue to push the AEMASE goal of facilitating the international collective effort to increase pragmatism and progress in Science Education in schools across nations and continents.



Professor Odile Macchi



Professor Giancarlo Vecchio

Co-Chairs, AEMASE Rome Conference Organising Committee

List of Abbreviations

AEMASE	African-European-Mediterranean Academies for Science Education
AIMS	African Institute for Mathematical Sciences
AKT	Association Karamba Touré (Mali)
ALLEA	All European Academies
ANCEFN	Argentine Academy of Sciences
ANISN	National Association of Natural Science Teachers (Italy)
ANSTS	Académie Nationale des Sciences et Techniques du Sénégal
BA	Bibliotheca Alexandrina
CERN	European Organisation for Nuclear Research
CNES	Centre national d'études spatiales (France)
CP	Pedagogical Counselors (Haiti)
CPD	Continuing Professional Development
EFACAP	Ecole fondamentale d'Application - Centre d'Appui Pédagogique (Haiti)
ERA	European Research Area
FMoGE	Federal Ministry of General Education (Sudan)
FOJEPDE	Association Forum des Jeunes pour la Promotion du Développement (Cameroon)
FUMEC	Fundación México-Estados Unidos para la Ciencia
HaCE	Haciendo Ciencia en la Escuela (Doing Science at School) (Argentina)
HISSET	UNESCO History of Islamic Science, Engineering and Technology
IAP	InterAcademy Panel
IBE	Inquiry-Based Education
IBME	Inquiry-Based Mathematics Education

IBSE	Inquiry-Based Science Education
IANAS	Inter-American Network of Academies of Sciences
IANAS SEP	IANAS Science Education Programme
ICT	Information and Communication Technology
IDE	Institute of Development of Education
INNOVEC	Innovation in Science Education
IRD	Institut de Recherche de Développement
ISESCO	Islamic Educational, Scientific and Cultural Organisation
ISTIC	International Science, Technology and Innovation Centre (UNESCO)
JCAD	Les Jeunes Chercheurs Associés pour le Développement (Cameroon)
JSS	Association la Jeune Société du Savoir (Mali)
KNAW	Koninklijke Nederlandse Akademie van Wetenschappen (Royal Netherlands Academy of Arts and Sciences)
LAMAP	La main à la pâte (Foundation)
MAcS	Minor Academy of Sciences of Ukraine
MENA	Middle East and North Africa
MoES	Ministry of Education and Sport (Albania)
MOOC	Massive Online Open Courses
MTA	Hungarian Academy of Sciences
NAMES	North Africa and Middle East Network of Science Centres
NAS	National Academy of Sciences, USA
NASAC	Network of African Science Academies
OIC	Organisation of Islamic Cooperation
PANS	Pan-African Network of Science Centres

PSC	Planetarium Science Center, Bibliotheca Alexandrina
RECSAM	Regional Centre for Education in Science and Mathematics
RSAS	The Royal Swedish Academy of Sciences
SAASTEC	Southern African Association of Science and Technology Centres
SAILS	Strategies for Assessment of Inquiry Learning in Science
SCI	Science Clubs Initiative, Bibliotheca Alexandrina
SE	Science Education
SEH	Science Education Hub (The Netherlands)
SERCE	Segundo Estudio Regional Comparativo y Explicativo (Second Regional Comparative and Explanatory Study)
SID	Scientiam Inquirendo Discere (Italy)
SNAS	Sudanese National Academy of Sciences
STEM	Science, technology, engineering and mathematics
SZTE	University of Szeged (Hungary)
TEH	Transformer l'Enseignement en Haïti
ToT	Training of Trainers
TWAS	The World Academy of Sciences
UEMF	Euro-Mediterranean University of Fez

Conference Co-Sponsors and Partner Organisations



ALLEA, the Federation of All European Academies, was founded in 1994 and currently brings together 58 Academies in more than 40 countries from the Council of Europe region. Member Academies operate as learned societies,

think tanks and research performing organisations. They are self-governing communities of leaders of scholarly enquiry across all fields of the natural sciences, the social sciences and the humanities.

Independent from political, commercial and ideological interests, ALLEA's policy work seeks to contribute to improving the framework conditions under which science and scholarship can excel. Jointly with its Member Academies, ALLEA is in a position to address the full range of structural and policy issues facing Europe in science, research and innovation. In doing so, it is guided by a common understanding of Europe bound together by historical, social and political factors as well as for scientific and economic reasons.



The **Compagnia di San Paolo** was founded in Torino in 1563 as a charitable brotherhood and is one of Europe's most important private foundations.

The Foundation participates in society's activities by pursuing ends that are of public interest and social utility, with the aim of favoring civil, cultural, and economic development in the community in which it is active. The areas in which the Compagnia acts are those of scientific, economic and juridical research; education; art; conservation and enhancement of cultural heritage and activities and of heritage sites; health; assistance to the socially deprived categories. These areas of intervention go side by side with interdisciplinary activities, which are more and more needed in order to respond to the complexity of modern life.

The Foundation's activities are financed with the income produced by the estate over the course of centuries and which the Compagnia has the task to pass on intact to future generations.



the global network of science academies

IAP, the global network of science academies, was launched in 1993 and is comprised of 107 academies. IAP is hosted by TWAS, The World Academy of Sciences for the advancement of science in the developing world, and receives core funding from the Italian government. Its primary goal is to help member academies work together to advise citizens and public officials on the scientific aspects of critical global issues. Improving science education and science literacy around the globe is another key area of IAP activity.

IAP is particularly interested in assisting young and small academies achieve these goals and, through the communication links and networks created by IAP activities, all academies will be able to raise both their public profile among citizens and their influence among policy makers. IAP helps to create science academies in countries where academies do not exist and assists young and small academies to become more prominent in their own countries. IAP also sponsors programmes for young scientists designed to help them build strong foundations for successful careers and to more effectively engage decision-makers.



Since its creation in 1666, the **Académie des sciences** has been committed to the development of sciences and advises the government in those matters. Independent and perennial, under the protection of the President of the French Republic, it is one of the five academies that are part of the Institut de France.

Today, with 259 Members, 130 Foreign Associates Members and 95 Corresponding members, elected among the most distinguished French and Foreign scientists, the Académie is multidisciplinary and widely represented on the international stage. Its members accomplish their works within thematic reflection committees in close interaction with the instances of statutory governance. The Académie fulfils five fundamental missions: encouraging the scientific life, promoting the teaching of science, conveying knowledge, fostering international collaboration and ensuring a dual role of expertise and advice.

Académie Hassan II des Sciences et Techniques

The **Académie Hassan II des Sciences et Techniques** was established by His Majesty the King of Morocco, Mohammed VI, on May 18th, 2006. It counts 90 members, both national and foreign. The Académie seeks to contribute to the promotion and development of scientific and technical research and its national policy, the evaluation and funding of scientific and technical research programmes, and the integration of scientific and technical research activities in the social and economic environment at national and international levels.

Among its many goals, the Académie works for the dissemination of science by organising panels and scientific events, publishing relevant material, and opening science libraries. It actively monitors scientific developments and carries out studies and surveys for the benefit of research and technical innovation. The Académie also seeks to kindle the scientific spirit within the Moroccan society and works to provide local scientists and researchers with a special forum for debate and interaction.



The **Académie Nationale des Sciences et Techniques du Sénégal (ANSTS)** is a Learned Society, founded in 1999 with the intention of harnessing Senegal's intellectual resources for the benefit of the country's scientific, technological, economic, and socio-cultural development. The ANSTS seeks, through its expertise, to provide the Senegalese Government with scientific advice that helps in defining and implementing national science and technology policy.

ANSTS membership is on the basis of merit, following an examination of their qualifications and scientific achievements and a presentation at the Academy. Among its objectives, the Academy works to find scientific and technological solutions to national economic and social challenges. It also devotes substantial efforts to expanding, intensifying, and diversifying its work, particularly in cooperation with international Academy partners.



ACCADEMIA NAZIONALE DEI LINCEI

Founded in 1603, the **Accademia Nazionale dei Lincei** is the oldest science academy worldwide. The Academy promotes excellence through its Fellowship which included, among many other prestigious names, Galileo Galilei. The Accademia Nazionale dei Lincei, placed within the sphere of the Ministry of Cultural Heritage, is considered the highest Italian cultural institution. Since 1992, the Academy is the President of the Italian Republic's scientific consultant and has recently been granted with his High Permanent Patronage.

The Academy organises national and international conferences, meetings and seminars. It also promotes and carries out research activities and missions, confers awards and grants, and publishes the reports of its own sessions as well as the proceedings of the conferences, meetings and seminars organised. Finally, the Academy provides – either upon request or on its own initiative – advice to public institutions and also drafts proposals.



The **Bibliotheca Alexandrina** aims to be a centre of excellence in the production and dissemination of knowledge and a place of dialogue, learning and understanding between cultures and peoples. The unique role of the Library of Alexandria, as that of a great Egyptian Library with international dimensions, focusses on four main aspects that seek to recapture the spirit of the original ancient Library of Alexandria. It aspires to be: the world's window to Egypt; Egypt's window to the world; a leading institution of the digital age; and a center for learning, tolerance, dialogue and understanding.

The Bibliotheca Alexandrina is not only a library with millions of books, but also offers an internet archive, several specialised libraries, four museums, a planetarium, a cultural panorama (the Culturama), the interactive VISTA research environment, several academic research centres, 15 permanent exhibitions, four art galleries, and a conference centre. It also hosts numerous research institutions and networks.

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AEMASE stands for “African-European-Mediterranean Academies for Science Education”. This Conference is an initiative of five prestigious institutions, including Science Academies in Africa and Europe, and gathers 50 delegates selected from African, European and Mediterranean countries. Its venue is the prestigious Accademia Nazionale dei Lincei in the very centre of Rome.

At primary and secondary school, science education (SE) is currently viewed as being in a state of crisis calling for attention in many countries. The organisers of this conference believe that the present social and economic challenges of most countries require urgent and long-term decisive action to renew SE for young people, with an emphasis on early education at primary and lower secondary school levels, when a human being’s curiosity is usually at its highest. For this, they believe that “Inquiry-Based Science Education” (IBSE) is the best pedagogical approach.

Therefore, the AEMASE Conference seeks to foster the concrete dialogue between developed and developing countries for renewing SE and create, encourage or empower informal partnerships within participating countries between scientists of Academies and representatives of Ministries of Education for the implementation of IBSE in schools and the development of informal SE for the youth.



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