International AEMASE Conference on Science Education

Conference Report

prepared by

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

Organising Committee:
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
Ahmadou Wague, Académie Nationale des Sciences et Techniques du Sénégal

Venue of the Conference:
Accademia Nazionale dei Lincei
Palazzo Corsini
Via della Lungara 10
Conference website: www.lincei.it/convegni/AEMASE

Thanks and appreciation are due to the following organisations for generously co-sponsoring this Conference:

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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
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,


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International Collaborations

Assessing the Outcomes of Inquiry-Based Science Learning

Professor Benő Csapó
MTA-SZTE² Research Group on the Development of Competencies, University of Szeged, Hungary

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.
2 MTA: Hungarian Academy of Sciences; SZTE: University of Szeged
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).

References:


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 immediate 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).

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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.