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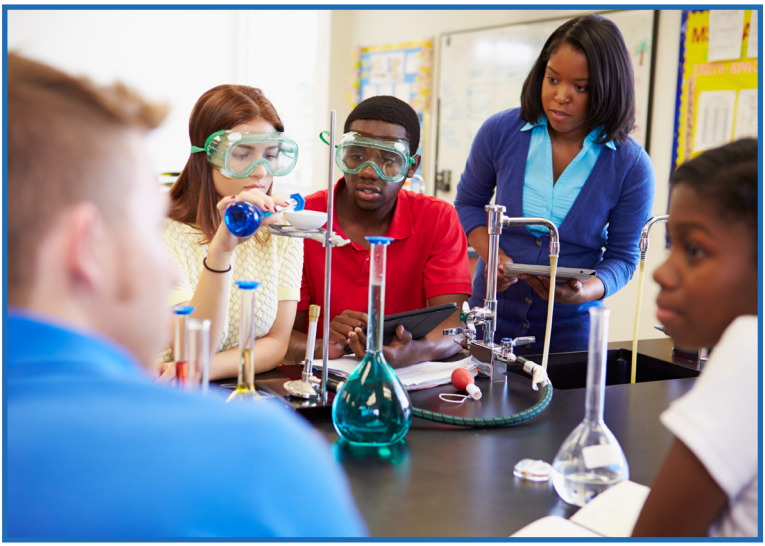

International AEMASE Conference on Science Education

Conference Report

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ACCADEMIA NAZIONALE DEI LINCEI

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

International Collaborations[1]

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.

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

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).

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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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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