AEMASE

AFRICAN EUROPEAN MEDITERRANEAN ACADEMIES FOR SCIENCE EDUCATION

Inquiry-Based Science Education

Primer to the international AEMASE conference report
Rome, 19-20 May 2014

Science education encourages children to develop an understanding of the world around them, and how to think critically about problems and solutions. These are key skills for citizens of the 21st century, who will need to address serious global issues such as climate change and economic crises. **Inquiry-Based Science Education (IBSE)** is a form of **science education (SE)** that - unlike the traditional model where the teacher provides facts and the students learn them - gives children the opportunity to explore "hands on", to experiment, to ask questions and to develop responses based on reasoning.

This short booklet provides a snapshot of concepts and international initiatives relating to IBSE and is based on the proceedings of a recent conference involving experts and representatives from six continents. It serves as a springboard for better understanding how Inquiry-Based Science Education can be supported in schools around the world.

Science education is key for modern societies

Children in the 21st century are growing up in a world facing complex global issues. They will need to deal with the impacts of climate change, mass human migration to urban environments and health threats including obesity, chronic disease and emerging infectious diseases.

Scientific literacy and critical thinking will help them to understand such issues and support their future efforts to address these enormous societal challenges. Providing an adequate science education to children enables them to learn how to reason logically, and it enables their growth as future active citizens.

What is Inquiry-Based Science Education?

Traditionally in science education, a teacher relates facts to students, who in turn learn those facts. IBSE takes a more student-centred approach to teaching, and puts the focus instead on questions and problem-solving.

Students learn through reasoning and doing, through asking questions, carrying out experiments, weighing up evidence and considering alternative hypotheses. Thanks to their own curiosity and the skills of scientific inquiry they develop, students learn about the facts rather than having them presented to them as a fait accompli. The IBSE approach can thus motivate children to be interested in science and to develop scientific literacy and critical thinking skills.

It is important to introduce IBSE to children in a manner that harnesses their innate curiosity, which is particularly strong when they are in primary-level schooling between the ages of about six and 12.

Why does IBSE matter?

Education in 20th century focussed on reading, writing and counting. In the 21st century we need to focus more on building reasoning skills early in life, and this is where inquiry-based educational approaches can play an important role.

To paraphrase the French mathematician Henri Poincaré, just as a house is more than a collection of stones, science is more than a collection of facts. If children develop the skills to not only understand facts but also their wider context, how they relate to each other and the rational thinking that underpins them, scientific literacy and engagement can be enriched.

Scientific literacy and critical thinking can contribute to sectors that bring economic advantages, such as technology and innovation, both in developing and developed regions of the world. Critical thinking skills can also, in theory, help to prevent extremist ideological thinking of the kind that can lead to mass conflict.

TEACHERS ARE CRITICALLY IMPORTANT

An effective teacher can inspire students to learn, love and engage with a subject. In IBSE, the key enabler is the teacher, who needs to be able to develop the confidence and practical materials to support students as they learn through asking questions and solving problems.

Many countries have programmes to grow IBSE, but the economic crisis is hampering teacher training and professional development. This needs to be addressed by scientists, educators and policy makers: it is important that teachers can avail of high quality professional development training and that they are supported in the change of mindset and student-teacher interaction that teaching IBSE requires.

More generally, for efforts to improve SE to have the required impact, the status and salaries of teachers in basic education needs to be raised in many countries, schools need to be funded adequately and teachers need to be supported in professional development.

How are nations building IBSE?

There are numerous IBSE initiatives that are ongoing around the world. In developed countries, SE is often inadequate and this threatens innovation and economic growth, while in developing countries SE is important for continued growth and development.

Some examples of supporting IBSE include establishing networks of 'Science Learning Centres' to support teacher development, increasing awareness of IBSE and practical applications of IBSE in areas such as health, and creating special IBSE-based materials to enhance science curricula.

The Rome Conference

In May 2014, the International AEMASE Conference on Science Education hosted by the *Accademia Nazionale dei Lincei* brought together representatives from more than 30 countries across five continents to speak about SE initiatives, share best practices and identify challenges and needs. From national projects to international collaborations, the Conference offered participants the chance to engage in further development of worldwide IBSE and establish valuable contacts for future exchanges.

IBSE in EUROPE

Several initiatives are underway to strengthen SE in European nations, and many of them focus on IBSE. In some countries, science education centres, organised into networks, are offering teachers the opportunity to train and develop confidence in science subjects and IBSE, and to date these have been working well.

It is important that schools, education centres and universities work together on science education, and place the learning in a cultural context so that students engage even further.

Internet safety must be a priority for children, and here parents can collaborate with schools to increase the awareness of issues, and develop good practice to stay safe online.

Competitions and fairs can provide a crucible for SE and particularly IBSE - students with an interest and aptitude for science can further develop their skills and learning in such extracurricular activities. And it's not just the students who can benefit from extra inspiration: lectures for teachers from distinguished scientists, and awards for teachers in science education can also lift the spirit.

IBSE in practice - Questions that make you think

Asking questions is a core activity in IBSE. In the Netherlands, the Radboud Science Awards encourages researchers to develop research activities for children and write a book based on the project. Some of the questions children asked during this process include:

"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?"

IBSE in practice - Encouraging healthy eating

In Italy, a project to promote healthy eating among primary school children is taking an inquiry-based approach. Rather than providing 'rules' about what to eat, children learn about the structure of their bodies. Then they learn what puts their health at risk and how to avoid those risks. Ultimately, they become actively involved in healthy behaviours, and their families collaborate too.

IBSE in AFRICA

There are a range of initiatives relating to IBSE in Africa, particularly looking to raise awareness of IBSE as a form of SE that can motivate children and build critical thinking skills.

Challenges can include nationally mandated educational curricula and a lack of resources for training, and projects are seeking to improve the quality of SE and teaching within these contexts.

In Egypt, IBSE is getting a boost from an ambitious project that is introducing students and teachers to innovative forms of science teaching and learning, and encouraging the formation of science clubs. Materials developed through the initiative include a series of fables written to encourage children to apply scientific knowledge as a creative tool and to introduce "systems thinking."

IBSE Snapshots from LATIN AMERICA, AUSTRALIA and ASIA

IBSE initiatives are also in progress outside of the AEMASE geographic region, such as SE initiatives in Malaysia, where a pilot programme implemented IBSE training and found it had positive outcomes for teachers and students, in Argentina, where resources and workshops for teacher training, and in Australia, where the "Primary connections" SE programme (funded by the Australian Government and Nobel Laureate Professor Brian Schmidt) is being implemented in more than 70 per cent of primary schools with a potential outreach of 1.4 million children.

Building IBSE after a natural disaster

The 2010 earthquake in Haiti was a devastating blow for the country. The French TEH project (*Pour la Transformation de l'Enseignement en Haiti*) was initiated following the quake to support schools there. It seeks to improve science teaching by introducing the "hands-on" LAMAP method, a form of IBSE that emphasises investigation: the teacher proposes situations that prompt the students to investigate and then reason to reach conclusions.

International Collaborations Driving IBSE

In recent decades, IBSE has emerged as a prominent alternative to traditional SE, and it has been the subject of international research - the European Union's Framework Programme 7 supported around 20 international projects aimed at improving SE, with many of them focusing on IBSE. The FP7-funded Fibonacci Programme successfully disseminated Inquiry-Based Science and Mathematics Education in Europe through booklets, conferences, field visits, training sessions and "twinning", or transferring knowledge between countries.

In Africa, the Network of African Science Academies (NASAC) includes 19 members from a range of nations, and since 2007 it has viewed IBSE as a preferable approach to teaching and learning science. Its work on surveying IBSE activities has already identified a number of key factors, including mobility/immigration issues for scientists, the need for regional approaches, the role of policymakers and the importance of scientists and teachers interacting.

Separately, the Library of Alexandria in Egypt is seeking to build a Pan-African Network of Science Centres - informal, hands-on science communication centres that can complement formal education, improve science communication in the media and stimulate discussion around policies.

In Mexico, IBSE has been boosted by the non-profit Mexican organisation Innovation in Science Education (INNOVEC), which has worked with international partners and through international conferences to strengthen IBSE initiatives in Mexico (reaching more than 400,000 students and around 10,000 teachers) and in other countries.

Challenges for IBSE

While IBSE is a route to enabling children to think critically and become scientifically literate, there are several challenges to overcome for this approach to be adopted widely.

The goals of IBSE are often ill-defined, and the field would benefit if the expected outcomes were more precisely defined, operationalised and made measurable. Measuring the impact of IBSE - including the ability of students to use skills of inquiry, understand "big ideas" of science and apply scientific knowledge and reasoning - will strengthen its case further.

Teacher training is a vital element of IBSE. While many teachers are engaging in training to help them deliver IBSE with confidence, there remains a job to do to convince teachers more widely that IBSE is a worthwhile approach. Teachers are often bound by textbooks and examination requirements for students, and IBSE needs to be afforded time and, in some cases, a change in mindset among the teachers.

Resources are an issue in education, particularly in developing countries. Teachers and schools must work with materials that are available to them, and schools need to replace teachers who are undergoing training.

IBSE takes time to bed down in a school or system - this process can take years, and policy-makers, teachers, parents and students need to be realistic about this time-frame.

What is needed now for IBSE?

In order to enable IBSE - and to improve SE more generally - we need to focus on:

Teachers - we need more trained science teachers, and we need the efforts of those teachers to be recognised and rewarded.
Partnerships - to date, initiatives have been successfully implementing IBSE in nations and regions. Partnerships between centres and between countries foster the transfer of knowledge and best practice, and they will help to scale efforts to implement IBSE.
An International Centre - we should consider creating a single centre in a host country where teachers, trainers and scientists from around the world can meet to discuss and learn about IBSE and then continue to support each other online.

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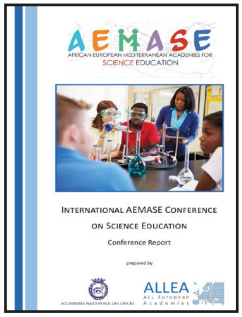

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