ACADEMY OF SCIENCE OF SOUTH AFRICA

INQUIRY-BASED SCIENCE EDUCATION (IBSE) FOR GIRLS/PRIMARY CONNECTIONS WORKSHOP

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OVERVIEW OF THE ACADEMY OF SCIENCE OF SOUTH AFRICA (ASSAf)

Nthabiseng Taole
Academy of Science of South Africa

The Academy of Science of South Africa (ASSAf) was established in May 1996 and the Academy of Science of South Africa Act of 2001 recognised the organisation as the official national academy in the country. It was formed in response to the need for an Academy of Science congruent with the dawn of democracy in South Africa. The mandate of the Academy encompasses all fields of scientific enquiry, and its membership includes the full diversity of South Africa's distinguished scientists. ASSAf strives to be the apex organisation for science and scholarship in South Africa.

ASSAf currently has 338 members from a variety of disciplines including the natural, humanities and social science fields. It is governed by the ASSAf Council, which is made up of 13 members of the Academy and a representative appointed by the Minister of Science and Technology as well as the Executive Officer. The Academy currently has 21 staff members.

In order for ASSAf to offer advice to government and other stakeholders on policy and other issues of public concern, two types of studies are undertaken:

- Consensus studies, which reflect the deliberations of a carefully selected Study Panel and lead to a set of strong policy recommendations based on consensus.
- Forum studies, which are convening types of activities, providing a means for invited experts to gather to discuss issues, make presentations and exchange views on topics in a broad field. The deliberations of a forum study panel do not aim to make recommendations based on consensus, but knowledge is translated into practical recommendations by pooling expertise.

The Academy has undertaken various studies, mainly, under three broad themes: Health and Related Sciences; Education and Humanities; and Environment, Water and Energy.

The academy's Scholarly Publishing Programme is aimed at the implementation of the ten recommendations of the 2006 consensus report on *A Strategic Approach to Research Publishing in SA. The* activities of this programme include:

- Discipline-grouped peer review of South African scholarly journals
- The completed consensus study on *A Strategic Approach to Scholarly Publishing in Books in SA*
- The development of an online course in scientific writing
- Hosting the National Scholarly Editors' Forum (NSEF) on an annual basis
- A study of incentives for editors
- The implementation of a SciELO-type national platform for open access publication of scholarly journals in South Africa.

The activities of the Communication and Publications division ensure that ASSAf is appropriately profiled and that the ASSAf publications are of a consistently high standard. The *South African Journal of Science* is currently being placed on an open access platform (SciELO SA) and *Quest* magazine is freely distributed to approximately 4500 public high schools and 1500 public libraries. ASSAf also participates in several national and international activities.

SESSION 1: INTRODUCTION TO IBSE FOR GIRLS

Facilitator: Nthabiseng Taole
Academy of Science of South Africa

WELCOME AND INTRODUCTION
Roseanne Diab
Academy of Science of South Africa

Prof. Diab welcomed all the participants on behalf of the co-hosts of the workshop, ASSAf, NASAC and TWOWS.

OVERVIEW OF THE THIRD WORLD ORGANISATION FOR WOMEN IN SCIENCE (TWOWS)
Sophia Huyer
Third World Organisation of Women in Science

TWOWS is hosted by the Third World Academy of Sciences (TWAS) in Trieste, Italy and is overseen by an Executive Board made up of members from Africa, Arab states, Asia and Latin America. Currently TWOWS has approximately 3500 members from 90 countries as well as associate members from the developed world and associate male members. The mission of TWOWS is:

- To promote greater participation of women scientists and technologists in the development process of their countries and in the international community
- To increase women's access to science and technology
- To implement programmes to promote women's participation in and contribution to science and technology in developing countries
- To engender the science system
- To provide support and networking services to its members.

The next major event of the organisation is the 2010 General Assembly in Beijing, hosted by the China Academy of Sciences, at which the TWOWS-TWAS-Elsevier Foundation Prizes for Young Women Scientists will be announced. TWOWS has approximately 1500 members in Africa, and 80% of the TWOWS PhD fellowships are granted to women in African countries, most of which are held in institutions in South Africa. TWOWS works at the national level in Congo, Nigeria, South Africa, Sudan and Tanzania, linking up with existing groups to promote networking and mentoring among women scientists. TWOWS collaborates with ASSAf on Gender and Science Education. The Founding President of the organisation was an eminent woman scientist from Swaziland, Dr Lydia Makhubu.

TWOWS has recently undergone a revisioning and strategy process which resulted in a focus on six areas, namely:

- Promote women's leadership in science through providing fellowships and working with other groups to provide re-entry and reintegration grants, postdoctoral fellowships and leadership development activities at national and regional levels. A number of activities are being developed around leadership and mentoring workshops in Africa
- Membership mobilisation in terms of providing resources and information for networking and mentoring
- Working with girls at younger ages in primary and secondary school level through several different networks to develop activities around promoting science and developing role models in terms of gender in inquiry-based science education
- Institutional capacity building through partnering with host institutes through the PhD fellowships and other science organisations to incorporate more women into their activities or to recognise the contributions women can make to an organisation
- International campaign to educate people on the contributions that women are able to bring to science and how science can support women around the world
- National chapters to link up with existing groups to promote networking and mentoring among women scientists; promote policy and education; and extend membership of the organisation in those countries.

TWOWS' education-related activities operate primarily at tertiary level and include:

- **PhD fellowships**
  To date, 175 PhD Fellowships have been provided to women in Africa and the developing world of which 75 have graduated. The Fellowships are held at institutions in the developing world to promote South-South exchange of knowledge, collaboration and networking for women scientists in the developing world. The programme is supported primarily by the Swedish International Development Cooperation Agency (SIDA). All PhD Fellowship holders are involved in mentorship and role model activities at secondary schools.

- **TWOWS national chapters**
  In general, these are bodies exist to encourage networking around gender and science at national level. In addition to the chapters in sub-Saharan Africa, there are also chapters in Egypt, Jordan, Yemen, Brazil, India and Indonesia. The activities of the national chapters include the dissemination of information and working among national decision makers and stakeholders to promote TWOWS goals. Regional conferences have been held in Nigeria, Yemen and India.

- **Collaborations with like-minded organisations**
  TWOWS works closely with TWAS, IAP, UNESCO and other global science institutions to mainstream gender, bring in more women and address gender dimensions in science education at all levels. The scientific world is interested in finding ways to bring more women and girls into their work. Much work is being done with TWAS to help implement programmes and measures to bring more women into their activities.

  The InterAcademy Panel (IAP) is a medium that works primarily through Academies of Sciences, which have begun to work more closely with society to reach the youth and young women scientists with the assistance of TWOWS. Recently the Inter-American network of Academies of Science (IANAS) launched a working group for Women for Science as a follow-up to the relevant IAP report, with a focus area on education at all levels. The first meeting of the IANAS working group will be held in June in conjunction with the IANAS Workshop on Science Education in Brazil, when a Teachers' Day on Science Education Capacity Building will be held for about 200 secondary school teachers from Brazil. The NASAC plan of action for Women for Science in Africa promotes education, and TWAS is working with TWOWS to highlight the importance of the available opportunities to present women scientists as role models.

  Other international organisations that collaborate with TWOWS include:
  - Gender Advisory Board to the United Nations Commission on Science and Technology for Development (UNCSTD)
  - United Nations Educational, Scientific and Cultural Organisation (UNESCO)
  - American Association for the Advancement of Science (AAAS)
  - National Academies of Science, USA.

- **E-networking**
  This is focused on supporting members of TWOWS on a regional and an individual bases. The website on gender and science education resources will be developed for the IANAS Women for Science Working Group.

Currently TWOWS has individual members. The constitution is being revised, and one of the recommended changes will be to have connections with organisational entities at the regional, national and international levels. The requirements for membership are that the applicant must be involved in a science activity, have a science degree or a job in science or in policy around science issues, and be a developing country national. The inclusion of women from other parts of the world is being re-examined. An honorary membership level is being considered so that prestigious women scientists can be recognised. Men cannot become full members, but are encouraged to become associate members. Annual subscription fees are nominal and go towards the National Chapter, where applicable. Membership application forms are available on the TWOWS website as well as the relevant National Chapter.

OVERVIEW OF THE NETWORK OF AFRICAN SCIENCE ACADEMIES (NASAC)

Jacqueline Olang
Network of African Science Academies

NASAC was founded in 2001 as an independent forum for African Science Academies to provide authoritative science advice for policy formulation towards economic, social and cultural development in Africa. NASAC currently has 16 members. The organisation is governed by a General Assembly, comprising the Presidents of the member Academies of Science and an Executive Committee. Ad hoc committees help implement projects or give advice on specific topics, and the Standing Committees assist NASAC in fulfilling its mandate. The NASAC Secretariat works in close contact with the Executive Officers/ Secretaries from each Science Academy in the continent.

NASAC assists in establishing Academies where none exist, empowers existing Academies, provides an independent platform for credible advice and makes the voice of science heard by scientists and policy-makers on the continent.

Some of NASAC's key successes to date include:

- The launch of critical flagship programmes on water, women and science education
- The creation of an independent advisory Expert Group
- The enhancement of members' capacities at Secretariat level
- The increase in NASAC membership
- Commencement of the process towards legal self-sufficiency.

The challenges faced by NASAC in trying to engender science on the continent are like those of the National Academies of Science in Africa, namely:

- Limited resources, with the majority of the Academies needing to be strengthened and transformed from static private men's clubs to dynamic 'organisations'.
- Membership is inhibitive in attracting younger scientists of both sexes, even those with academic merit.
- Most of the member Academies act locally and in isolation, even on common critical problems, with a limited sense of collective action.

In order to overcome these challenges, NASAC has identified three specific priorities:

- Improve communication: encouraging the voice of female scientists to be heard, networking, participation in the local and international forum and interaction with policy and decision makers.
- Implement the vision: provide strategic support for female scientists for inclusion as members of Science Academies; encourage best practices for science in interaction with society; hold meetings with policy-makers where female scientists are profiled; and develop funding opportunities and encourage the creation of a national science fund.
- Identify strategic partners: The NASAC membership forms the critical strategic partners, supported by like-minded organisations, to enhance the priorities of organisation.

NASAC supports networks in areas of critical importance to development in Africa by sharing best practices, developing joint projects and identifying training needs scientists. The NASAC workshop on Women for Science in 2009, where key recommendations for Science Academies were identified, was attended by female representatives from Academies in the continent. The recommendation concerning working with younger girls was relevant to the discussion around encouraging inquiry-based science education (IBSE) for girls. A paradigm shift is required by female scientists in Africa if they are to harness the resources available to ensure their increased participation in science and technology.

INTRODUCTION TO THE IBSE FOR GIRLS PROJECT

Roseanne Diab
Academy of Science of South Africa

Funds were received for this project from the InterAcademy Panel (IAP), a body with membership from over 100 Academies of Science around the world, which has various initiatives to provide funding for project-related activities. ASSAf has partnered with NASAC, TWOWS and the Gender Advisory Board of the United Nations Commission on Science and Technology for Development to present this workshop.

As shown in the ASSAf and NASAC presentations, one of the real powers of the Academies of Science is their ability to network and to bring together experts from a wide range of fields. This workshop brings together people from various organisations and aims to look at ways to encourage girls and young women to enter into science at school and later on into science careers, as well as the interventions that should be introduced to nurture girls in science education.

One of the roles of Academies of Science is to provide evidence-based policy advice to government. The output from this workshop will be a policy-makers' booklet of approximately 12 to 16 pages that will provide recommendations on how to proceed into the future. It is anticipated that the discussions will enrich this product. The booklet will be presented to governments, both of South Africa and other countries within the network of NASAC. Funding of potential interventions would follow. Two of these interventions will be presented to this workshop: PrimaryConnections (Australia) and La Main à La Pate (France).

AN INTRODUCTION TO INQUIRY-BASED SCIENCE EDUCATION

Diane Grayson
University of Pretoria

Before *talking* about IBSE it is important to *do* IBSE.

Several items were distributed and various activities were performed by the participants in order to give a brief demonstration of inquiry-based science. In the classroom environment, such activities could be focused on different education levels, and several scientific concepts would be developed over many hours.

IBSE can be traced back to the 1950s, to Jean Piaget, who developed a form of investigating children's thinking. In the 1960s and 1970s, scientists started to read the work of Piaget and became interested in conceptual development. Karplus used Piaget's work as the starting point for the systematic study of science learning in children and for developing curricula. Innovative science curricula were developed in the 1960s particularly for primary school children. Science education research gained more popularity in the 1970s and 1980s. Physics departments started to do systematic research on student thinking and understanding and developed curricula. Constructivism became a dominant theory of learning. From 1990 onwards, IBSE became the most widely advocated teaching approach among science education researchers and leaders.

The features of IBSE are:

- It is an inductive approach to learning, with an experience first followed by an observation from which the science is deduced. Traditionally, science teaching has used a deductive approach, which is less effective from a cognitive approach.
- Experience first, terminology later.
- It is guided by the constructivist theory of learning which says that knowledge cannot be transmitted. Knowledge is created by individuals on the basis of information received that is filtered through the learner's prior knowledge and prior experience. Teachers can transmit information but not knowledge. The teacher's role is to facilitate the construction of knowledge in each learner through carefully designed activities and questions to produce robust knowledge.

The prerequisites for teaching IBSE are:

- Confident teachers to deal with the potential for noise, mess and unpredictability, who have a good grasp of the subject matter

- Open-minded school principals
- Appropriate assessment systems.

Laboratories and scientific equipment are not a necessity for IBSE, and most activities can be done with simple equipment that is easy to acquire.

The first step in IBSE is to objectify the preconception through an experience. The next step is to cause a disequilibration and then to help bring about a conceptual change. This presents an opportunity to introduce a new scientific concept.

SESSION 2: SCIENCE EDUCATION FOR GIRLS
Facilitator: Nthabiseng Taole
Academy of Science of South Africa

GIRLS IN SCIENCE IN FRANCE AND EUROPE:

Odile Macchi
French Academy of Sciences

The history of women in science has come a long way since the 19th century, when a few science colleges for educating women appeared in some European countries and the United States. Only after the 1950s, when science education began to become more accessible to women, were doctoral degrees awarded to women, and women began to choose science as a career.

Women have sometimes wondered about the usefulness of mathematics in everyday life and have often preferred to focus their energy on beauty and the welfare of others. However, mathematics is evident in nature and in music, as much as it is in information theory and signal and image processing. Scientists depend on team efforts; they transmit their skills, share enthusiasm and push the imagination.

In the European Union (EU), women make up 41% of the PhD graduates in mathematics and computer science and 25% in engineering, manufacturing and construction. Few women are heads of scientific institutions and universities in the EU and only 17% of the EU-funded research grants are awarded to women. This signifies that women are generally absent from studying and practising science, and are therefore less likely to become successful scientists.

Despite the fact that research shows that girls are brighter than boys in all subjects at the secondary school level and that 80% of girls over the age of 18 benefit from tertiary education, there are very few successful female scientists in France. It is an established fact that the variability of brains is relevant to the specificity of each person rather than to their gender, and diversity is a powerful lever to improve quality in any context, particularly in the professional arena. Nevertheless, in France:

- only 39% of girls study science during the last year of secondary school
- the percentage of girls in science education at tertiary level remains low
- only 28% of computer scientists are women
- only one third of academics across the disciplines are women
- only 13.4% of girls graduate in information and communication technology sciences
- only 27.2% of girls graduate in the fundamental sciences.

The French Ministry of Education has put the following objectives in place in order to reverse this reality:

- An inter-ministerial agreement has been signed for equity between girls and boys, men and women
- All levels of education contribute to the promotion of equity between boys and girls
- The ‘Mission for Parity’ is a specific priority of the Ministry of Education
- An annual report, *Girls and boys: On the way to equity from primary to tertiary education*, is produced.

UNESCO and the international company L’Oreal, run an ambitious world programme which offers grants and fellowships, including five very prestigious rewards to women (one per continent) in the biological sciences. The annual UNESCO-L’Oreal Award winners are widely celebrated and respected in France. Four recent Nobel Prize winners have been women.

It is important for girls to have female role models who are achievers, particularly in science, technology and innovation, and who are confident in their knowledge of their subject. An appropriate learning environment that is conducive to building such confidence is also of value to girls.

HOW TO REACH OUT TO GIRLS AND ATTRACT THEM TO IBSE: EFFORTS IN AFRICA TO PROMOTE GIRLS IN SCIENTIFIC AND TECHNOLOGICAL EDUCATION

Eliezer Manguelle-Dicoum
Cameroon Academy of Sciences

The evidence that links education with numerous benefits, confirming that education is the foundation of development, is not disputed. In a 1999 article ‘Accelerating the Education of Girls and Women in sub-Saharan Africa: A Development Imperative’, Dr. Eddah Gachukia, founder of Forum for African Women Educationists (FAWE), underlined that education is the foundation of development and education of girls and women, and is a prerequisite for Africa’s development.
The World Conference on ‘Education for All (EFA)’, held in Thailand in 1990, emphasised the role of education in ensuring a safer, healthier, more environmentally sound world. The conference also identified education as a crucial contributor to social, economic and cultural progress, tolerance and capacity for cooperation. Many studies link basic education with the fostering of agricultural innovation, improving resource management and utilisation, promoting the use of new technologies and enhancing the capabilities of people to harness the knowledge they need for their own and their countries’ development.

The Dakar Conference in 2000 adopted the concept of ‘Education for all before 2015’ as fundamental in terms of one of the United Nations Millennium Development Goals (MDGs). Six main objectives in achieving these goals have been defined as follows:

- Early childhood care and education
- Universal primary education (UPE)
- Meeting the lifelong learning needs of youth and adults
- Adult literacy
- Gender
- Quality of education.

Women are the foundation of life in sub-Saharan Africa due to their multiple and critical role in the family as homemakers, caretakers, workers, producers and managers of food and environmental resources (water and fuel). Their education therefore acts as a catalyst for sustainable development. Their scientific education develops their critical thinking skills, self-esteem, mathematics, language and awareness of gender equality and human rights. It gives girls and women the opportunity to understand their potential and role in the holistic development of any nation. It is therefore important to attract girls and women to scientific and technological education, which begins with IBSE. IBSE for girls must be seen in the context of the EFA objectives, the most important of which are UPE, gender and quality of education.

Achievements in terms of UPE

According to the UNESCO 2009 EFA report, the average net enrolment ratios for developing countries have continued to increase since Dakar. Sub-Saharan Africa raised its average net enrolment ratio from 54% in 1999 to 70% in 2006, six times greater than it was in the 1990s. In 2006, approximately 75 million children in sub-Saharan Africa, 55% of whom were girls, did not attend school. Projections for 134 countries, accounting for nearly two-thirds of the children who did not attend school in 2006, suggest that about 29 million children will be out of school in 2015 in these countries alone. Children from poor households face major obstacles in accessing good quality education, while children from the wealthiest 20% of households have already achieved universal primary school attendance in most countries.

Trends in primary education are susceptible to public policy. Ethiopia, Malawi, Burkina Faso and Tanzania are making remarkable progress in increasing enrolment and reaching the poor, thanks to the implementation of policies such as the abolition of school fees, construction of schools in poor areas and increased numbers of teachers. However, poor education governance is still depriving millions of children in Nigeria and Pakistan of the opportunity of attending school. In 2006, 513 million students worldwide (58% of the relevant school-age population) were enrolled in secondary school, representing an increase of 76 million since 1999. Despite this progress, access to primary education remains limited for most of the world’s young people. In sub-Saharan Africa, 75% of children of secondary school age do not attend school.

Achievements in terms of gender

In 2006, of 176 countries with data, 59 had achieved gender parity in both primary and secondary education. About 66% of countries had achieved parity at the primary level. However, more than half the countries in sub-Saharan Africa, South and West Asia and the Arab states had not achieved gender parity at secondary school level. Poverty and other forms of social disadvantages exacerbate the existing gender disparities. For example, girls from poor households in Mali are four times less likely to attend primary school and eight times less likely to attend secondary school than those from rich households.

The education environment tends to be hostile to girls. The construction of separate toilet facilities for girls has increased girls' attendance in a rural primary school in Tanzania. Progress of girls in school is often hampered by teacher attitudes and gender-based textbooks that reinforce gender stereotypes.

What still needs to be done before 2015

Actions that still need to be taken in order to realise the MDG and EFA objectives include:

- Strengthening the links between education planning and child health provision using targets, interventions and more equitable public spending on the health sector
- Prioritisation of early childhood care and education
- Strengthening anti-poverty commitments by focusing on child malnutrition and public health systems
- Introduction of innovative social welfare programmes aimed at poor households
- Setting of ambitious long-term goals supported by realistic planning and budgetary allocation to ensure progress in terms of access to primary education, participation and completion of primary school
- Supporting equity for girls and disadvantaged groups by setting targets for reducing disparity in order to achieve equitable outcomes
- Raising the quality of education while expanding access to education
- Strengthening policy commitments to quality education
- Creating an effective learning environment for all students (appropriate facilities; well-trained teachers who are sensitised to gender; development of curricula with clearly identified outcomes, with the focus on learning)
- Commitment to reduce disparities
- Strengthening policies for reducing poverty and deep social inequalities that hinder progress with education for all
- Putting equity at the centre
- Raising quality standards
- Increasing national spending on education.

Scholarships and awards need to be given to girls for scientific and technology education. Poverty should not remain an obstacle to education for girls. Stories of women who are successful in science and technology need to be related and upheld. Negative social traditions need to be addressed. Scientific networks and associations of women need to be created in order to prepare girls for scientific careers.

Although there are many efforts across the world to attract girls to scientific and technological education, many disparities remain due to political, social environmental or cultural factors, or individual choices. The attempts to facilitate the access of girls and women to science education have to be made known and shared.

Questions and comments

Comment: Many challenges to attracting girls to science education and careers were mentioned. Quality education is the key to addressing these challenges, as it will generate interest among girls that would lead to longer-term growth in the number of female science students.

Comment: The interest of girls in science education is strongly linked to improving the quality of education for all. If the goals of EFA are achieved, it will be easier to interest girls in science education. It is necessary to train teachers to offer quality education. Girls face many difficulties, and many factors contribute to the current situation with regard to girls in science. Children and marginalised groups in general face similar challenges to those of girls in our societies.

Comment: The important issues related to girls at school, such as the vulnerability of adolescent girls, ought to be spoken about.

‘DOING SCIENCE’: PEDAGOGIES AND STRATEGIES TO ENHANCE PARTICIPATION AND PERFORMANCE OF GIRLS IN THE SCIENCES

Nnenesi Kgabi
Polytechnic of Namibia

In South Africa, girls tend to move away from the physical sciences when they go to high school, and if they do choose the natural sciences, they usually prefer biology or chemistry. A small research project was conducted in the North West province that traced the subject and career choices of a group of students from matriculation through to university. The study confirmed the move away from the physical sciences as girls move up the academic/career ladder. It however showed that girls choose careers in fields they believe will put them in a better position to help their communities e.g. health, environment, education and the social sciences. This shows that learners do not get sufficient information about science and technology-related careers and that the approaches used to the subjects are not ‘girl friendly’. Educators seemed to presume that only boys would choose to do mathematics and science at higher grade level, and girls were by normally instructed to take mathematics and physical science at standard grade level. Girl learners were also made to believe that they were not as capable as boy learners in terms of these subjects.

The saying, "Tell me and I forget, show me and I remember, involve me and I understand" explains the essence of IBSE. Inquiry means involvement through ‘hands-on’ activities that lead to understanding and involvement in learning. Skills are enhanced, and attitudes are developed that enable one to resolve questions and allow new knowledge to be constructed.

Some comparisons between inquiry-based and traditional teaching methods are shown in the following table.

	Inquiry-based teaching	**Traditional teaching**
Principle learning theory	Constructivism	Behaviourism
Student participation	Active	Passive
Student involvement in outcomes	Increased responsibility	Decreased responsibility
Student role	Problem solver	Director follower
Curriculum goals	Process oriented	Product oriented
Teachers’ role	Guide/facilitator	Director/transmitter

There are a number of pedagogies that are linked to IBSE, but the inductive or ‘bottom up’ approach to pedagogy is central to IBSE. This approach allows the learner to observe, experiment and construct knowledge through the facilitation of an educator. Problem-based learning is a problem-solving process of learning. Constructivism purports that through processes of accommodation and assimilation, individuals construct new knowledge from their experiences. In terms of being particularly relevant to girls, any pedagogy that is applied should be of demonstrable relevance to the immediate worlds of the students and it must enable them to analyse, theorise and intellectually engage with those worlds”, (Freire 1984). Dewey (1997) suggested that, “optimal learning and human development and growth occur when people are confronted with substantive, real problems to solve.” This implies that learners should be able to identify with the examples in textbooks and the items used in an activity.

IBSE strategies involve hands-on activities, group work, making space for critical thinking and for learners to own the learning process. Dewey (1997) believes that “curriculum and instruction should be based on integrated, community-based tasks and activities that engage learners in forms of pragmatic social action that have real value in the world.” Ideas are best introduced when students become aware of a need or a reason for their use, which helps them to make sense of what they are learning. Classroom activities need to be structured in a way that enables students to explore, explain, extend and evaluate their progress. The provision of sufficient support to promote learning when concepts and skills are first introduced to students is referred to as ‘scaffolding’.

Examples of IBSE were illustrated through interaction with the participants around rhythm and sound, a hot cup of tea and a collection of waste materials – to introduce physics and chemistry concepts, statistics, mathematics, properties of materials, economic sciences, health, creativity and technology. Facilitators should guide the discovery towards the objective of the exercise and select activities that are appropriate to the age group of the learners, using suitable materials from the learners' environment. IBSE does not necessarily require a fully equipped laboratory. It is important for the facilitator to understand the learners' world, their interests and career-path intentions, in order to apply IBSE effectively. Training teachers is essential in order to effectively implement IBSE.

IBSE is implementable, but requires a changed mindset of the people involved. It is a tool that can be used to enhance the whole education system to ensure that learners cope better at school, not only in science and often results in innovative graduates.

Questions and comments

Comment: Good and inspired teachers are the basis of IBSE.
Comment: Much has been learnt from this presentation. Teachers can use what is around them to teach any subject.
Comment: A mind shift is required in classrooms, and teachers need to realise that the old-fashioned equipment that one tends to find in school laboratories is not necessarily essential for teaching. Generally, a female teacher may encourage female learners more than a male teacher. All teachers must realise that the same amount of effort and encouragement should be given to both boys and girls.
Comment: Currently in South Africa, teachers are resistant to change and a mindshift is necessary. There is a need to reach out to teachers and work with them and not enforce change on them. These teachers would then need to spread the word about IBSE.
Comment: This approach needs to be exposed to student teachers before they become in-service teachers. A form of 'teaching national service' is suggested for the unemployed, matriculated people of our country to be teachers' assistants and after-school carers, to help children with basic skills such as literacy.

HOW TO INSTIL THE LOVE OF SCIENCE IN STUDENTS

Paul Nampala
Uganda National Academy of Sciences

Science subjects have been misrepresented in many countries, at all levels of education. It has been said that science is difficult to pass; that it is for boys and not for girls; that it is not rewarding; and that a scientific career requires much effort. Ironically, subjects such as economics apply mathematical models. Perhaps it is necessary to define the 'science' that is being promoted.

We know that science is the engine of economic growth for any country. The critical issues in development are addressed by scientific innovations in areas such as education, health, environment, human security and gender. If a nation does not cherish science, there will be no development. Despite the awareness of the importance of science, the statistics show a decline in the quantity and quality of scientists. The low levels of enrolment in science courses both at school and tertiary level cause great concern. Recent research shows that in order to enhance economic development, 40% of students need to enrol in basic science courses. Many African countries have enrolment figures of below 5%. It is unfortunate that science faculties and departments at some universities in the continent are closing due to a lack of interest among students. There is also a tendency to marginalise the sciences, possibly due to the world economic order and liberalisation policies that have brought about an increased number of private education institutions, most of which focus on the arts and humanities as these are more attractive to many students and require less financial and infrastructural investment.

The home environment provides an excellent setting for grooming young people to become scientists. Several studies have been done that indicate that there is a correlation between learners embarking on a scientific career and their parents or role models being scientists. We are surrounded by scientific principles, and their importance in our everyday lives should be demonstrated. The institutional culture of government departments and educational institutions at all levels needs to be changed through policies that favour science. Role models in the form of successful scientists are needed to attract and mentor students to and through science education and careers. Mentoring and networking programmes such as professional associations, school clubs, competitions and awards, as well as appropriate career guidance are necessary to encourage potential scientists, to enhance peer support and to nurture future scientists.

Uganda has upheld an affirmative action policy that offers a 2.5 point advantage to girls in accessing government scholarships for science education at university. Although there is much debate around this controversial policy, it has yielded results and brought more women into scientific careers. This policy should be considered as a commitment by government to close the gap between male and female scientists. Resource support is essential in order to practice, teach and learn science. Governments across the continent should take responsibility to ensure a supportive science teaching and learning infrastructure. Curriculum design is crucial to instil the love of science, and alternative models need to be explored that can provide flexibility and a learner-centred approach, such as IBSE. Compartmentalisation, opposed to generalisation of science subjects in the syllabus, remains a problem in Africa. Early specialisation should be avoided, and the focus of science education should be the skills base.

It is important to engage with the community around the public understanding of science and the role of science. Public concerns regarding scientific innovations should be handled cautiously, based on evidence and a respect for social values and ethical issues. Capacity building is crucial in order to enhance best practices in teaching and learning of sciences at all levels. It is important to begin the slow process of instilling the love of science in students as soon as possible.

SESSION 3: INQUIRY-BASED SCIENCE EDUCATION: THE EXPERIENCE

Facilitator: Jacqueline Olang
Network of African Science Academies

LA MAIN À LA PATE (LAMAP) ('HANDS IN THE DOUGH')

Odile Macchi
French Academy of Sciences

The French education system dictates that schooling is compulsory for children from the age of two or three until they are 16, and primary, secondary and tertiary education is free to all French nationals. Approximately five million children attend school in France. Although the education laws guarantee equal opportunities to all children, this has proved to be a challenge, as many children do not leave school with the mandatory skills. A pedagogy based on IBSE principles from the beginning of schooling would assist in meeting this challenge. France has 61 000 primary schools and 350 000 classes, and 80% of the teachers do not have a scientific background. The focus at primary school level is on reading, writing and arithmetic. In 1995, less than 3% of classes received science teaching, and there was no basic science material available in schools.

La Main à La Pate (LAMAP) was introduced in 1995 by Georges Charpak as a small-scale experiment in 344 classes. In 1998, the *Ten Principles of LAMAP* was published as a guideline for teachers, and the website was launched. By 2000, the programme had been extended to over 5000 classes, and the Ministry of Education launched a national strategy for quality science teaching. In 2002, a new curriculum, inspired by LAMAP, was developed for primary education. Each year, numerous resources for LAMAP are published, and currently approximately 50% of teachers that teach science have elected to use the LAMAP approach.

The implementation of the programme has been a partnership of the French Academy of Sciences, the National Institute for Pedagogical Research and the Superior Normal School in Paris. An interdisciplinary team of about 15 fulltime staff work on LAMAP and the programme receives funding from the Ministry of Education, other public institutions, various private and international organisations.

IBSE was adopted in France because of the following aspects of the programme:

- Development of cognitive skills: Progressive and autonomous building of knowledge through an inquiry approach
- Development of linguistic skills: Discussion and debates at the various stages of the inquiry process and writing up of the science notebook
- Development of interactions between pupils: Disagreements are settled by doing the experiments as a group, and social and life skills are learnt.
- Changing the perception of science: Europe needs more scientists, and the social perception of science needs to be raised.

The inquiry process involved in IBSE begins with questioning, forming a hypothesis, and doing experiments to arrive at a conclusion, involving both verbal and written communication. LAMAP offers continuous support to teachers and provides the following services from 15 pilot centres throughout the country:

- Documents and guidelines relating to LAMAP
- Support from scientists who offer expertise
- Material kits
- Evaluation and assessment methods
- Interdisciplinary projects
- Website and forums

Scientists are involved in voluntary assistance to teachers in the form of support: in the classroom, by tutors who are usually science students and spend half a day per week in primary schools to help the teacher, guide the learners and stimulate expression and reasoning, without interfering with the teachers' responsibilities; in collaborative projects; in the production of resources; from a distance; for teacher training and through sponsorship.

Some conclusions drawn from the implementation of the programme are:

- Over a period of ten years, science classes in primary school have increased from 3% to 30% and trials of LAMAP have been introduced in junior high schools.

- Teacher training and coaching remains the main challenge.
- Although positive feedback has been received from teachers, society and higher education, IBSE still requires rigorous evaluation.
- Effective coordination of LAMAP requires collaboration between the scientific community, the Ministry of Education and local authorities.

Questions and comments

Question: How is the skills base determined at each level?
Response: After the first few years of running LAMAP, the Minister of Education agreed that the curriculum for primary education should be changed in line with the principles of LAMAP. The process has commenced to change the curriculum for science in secondary schools according to LAMAP.

Question: Who pays the 15 full-time staff members of LAMAP, and are they employed on a permanent or contract basis?
Response: Most of the staff members are seconded to LAMAP from the National Institute for Pedagogic Research and other similar institutions for periods of four to five years

Question: LAMAP does not appear to focus on examinations. How has LAMAP overcome the issue of teaching for exams as opposed to teaching for knowledge?
Response: In France there are no examinations for primary school level children in terms of the knowledge base. Children are assessed for language, arithmetic and literacy. Assessment at secondary school level still needs to be clarified.

A SCIENCE AND LITERACY APPROACH TOWARDS GREATER INCLUSIVITY

Paul Webb and Mary-Grace Villanueva
CERTI, Nelson Mandela Metropolitan University

This presentation provided information on IBSE based on a project that had been conducted by the presenters, where the challenge of declining interest in science, a worldwide phenomenon among young people, was explored. The project was framed within notions of understandings of the nature of science and IBSE as well as language used to communicate science (talking, arguing, reading and writing science). The project aimed at working with in-service science teachers on a large scale, and it was conducted in a number of different contexts, in the classroom with children. The basic strategy for the project was to promote authentic scientific investigations, one of the learning areas in the South African education curricula. One of the ways to do this is to stimulate a classroom discussion that leads to questions being raised. The teachers help the children to divide the questions into investigable questions and researchable questions. The class must be guided to choose one of the investigable questions that can be explored in class. The children design their investigation and then carry out the investigation, keeping a science notebook in the language of their choice. It should be borne in mind that the teachers that worked with the presenters on the project teach science to learners in a second language. During the process, children are engaged in doing, talking, reading and writing science. Investigable questions are framed leading to inquiry investigation through talking, arguing and planning, predictions are made, the procedure is described, and conclusions are drawn. More information about the collected data comes from reading and discussions, expanding the learners' ideas and vocabulary. The learners are expected to argue their case during the presentation of their reports. This approach can be applied from Grade 1 through to Grade 12, with adaptations according to the age group.

The project was done in collaboration with the READ organisation in South Africa, which promotes reading for children. A large book was produced that gave information and ideas, particularly on magnetism, around a story. Discrepant events can be used by teachers to introduce ideas that would stimulate discussion in the classroom, such as insects walking on water, and simple apparatus is used. Learners frame an investigable question in their science notebook and make a prediction around the question. Assessment can be done around whether the prediction connects to prior experience; is clear and reasonable; relates to the question and gives an explanation and/or reason. The data are recorded in the learner's science notebook. The procedure and the collection of data can be assessed by considering whether they relate to the question, have a clear sequence, identify variables, include data organisers and state the materials that are needed. The investigation can be taken further with the guidance of teachers, consulting textbooks and library books. This process allows children and teachers to develop and generate their own knowledge.

Two books were used in the project, the large book for shared reading, containing a certain amount of information and the framework of the ideas, as well as a smaller book which has more information at a higher reading level for children to work through on their own. The strategy was tested in:

- township and rural schools
- private and Montessori schools
- high schools
- museum context
- Rally-to-READ schools.

The project looked at the reasoning skills of children and concluded that the reasoning skills of the experimental group improved significantly over those of the control groups. There were statistically significant improvements in pre-post test scores of the experimental group over the control group in:

- English reading skills
- listening skills in both English and isiXhosa
- isiXhosa writing skills.

The implications of this strategy for teacher development were that teachers would have to be taught about the various strategies as well as the importance of teaching language and science, looking at language as a way for teachers to facilitate the ability of learners to write in their home language and to communicate in English. Although IBSE is a good way for learners to test their ideas, scientific concepts must be understood from the process, and teachers must be comfortable in their own understanding of these concepts. The professional development for teachers involves choosing topics to help teachers develop their ideas.

IBSE does not involve doing ‘practical work’, because inquiry takes place within the context of language. Understandings will be constructed by writing (to formulise thoughts), reading (to learn science as well as learning to read for science), presenting science reports, and thinking.

Questions and comments

Question: Is it possible to incorporate the strategy for professional development for teachers in teacher training, and at what level could it be taught?
Response: The strategy could be incorporated at many levels, at a pre-service level as well as at an in-service level. The Nelson Mandela Metropolitan University has a short learning programme for scientific investigation.
Response: The strategy for teacher development should be incorporated over an extended period of time. The READ organisation plans to do this over three years by working with teachers once a quarter.

Question: How does this strategy promote inclusivity?
Response: The programme encourages more people to enjoy science and get a better understanding of the concepts. The project did not look at girls and boys in science. This would have to be investigated in the next phase of the project.

Question: What kind of gender-related problems were faced in working with IBSE in schools?
Comment: There is no difference between girls and boys in the application of LAMAP.
Comment: Girls in poor communities experience numerous social problems that result in girls leaving school at an early age.
Comment: Issues of culture and attitude are a challenge to bringing IBSE to girls.
Comment: TWOWS is interested in an analysis and evaluation of different countries on the participation of girls in IBSE programmes and whether they continue to careers in science. Based on other research on gender and science education, this would be a useful model. Other studies have shown that girls would benefit from good quality teaching and hands-on science that is relevant to the life of the learners. The varying confidence levels of boys and girls and dispute resolutions need to be discussed further.

OVERVIEW OF INQUIRY-BASED SCIENCE EDUCATION IN AUSTRALIA

Shelley Peers
Australian Academy of Sciences

Australia has eight states and territories with 8000 primary schools, 126 000 primary teachers, 2700 secondary schools, 123 000 secondary teachers and an average of 30 students per class. There are two national programmes in IBSE, both of which are initiatives of the Australian Academy of Science: PrimaryConnections and Science by Doing. The Australian Foundation for Science, a separate entity within the Academy, funded a proof-of-concept stage of the PrimaryConnections programme. Federal government agreed to fund the project once its success had been proved. The secondary school programme, Science by Doing, is currently in the pilot phase in 28 trial schools. The programmes look at how to scaffold teachers through the IBSE process and how to ensure learners are engaged in classroom activities. Science teaching is compulsory in Australia and is allocated 2.7% of teaching time per week.

The following were identified as reasons why primary science education had not been successful in previous years:

- Low priority for science in the primary school
- Overcrowding of the primary curriculum
- Unachievable syllabus requirements in science
- Inadequate resourcing of science education
- Limited access to quality in-service professional learning for teachers
- Low priority for science in the primary curriculum
- Overcrowding of the primary curriculum
- Unachievable syllabus requirements in science
- Inadequate resourcing of science education
- Limited access to quality in-service professional learning for teachers
- Limited opportunities for teachers (and trainee teachers) to see quality teaching of science
- Limited time for science education units in pre-service teacher courses
- Limited understanding by decision makers of the issues in the teaching of primary science
- Limited understanding of science itself in the school context by teachers, principals and decision makers
- Change-weary teachers
- Low teacher confidence.

Some of the findings about ways to assist teachers include:

- Ensure time for change over extended periods, up to ten to 15 years. Once-off workshops do not produce the required results
- Provide access to professional learning in order to change the belief patterns
- Address resourcing for IBSE
- Foster positive attitudes to change and the importance of incremental growth
- Encourage successful professional learning and teaching experiences
- Provide support to teachers.

A clear decision had been taken, with the help and guidance of the Australian Academy of Science, that science literacy was the purpose of primary school science. The framework of the Programme for international Student Assessment (PISA) describes science literacy as context (life situations that involve science and technology) and competencies (identify scientific issues, explain phenomena scientifically and use scientific evidence) that are influenced by knowledge (what you know about the natural world, about science itself) and attitudes (how you respond to science issues).

Science and literacy are mutually supportive. Literacy is essential in order to think and reason in science, and without literacy students have only restricted access to learning science. Without learning science, students have restricted access to understanding how the world works and how to make evidence-based decisions about their own health and well-being.

The PrimaryConnections Indigenous Perspectives Framework is designed to support teachers to link science, literacy and indigenous perspectives. PrimaryConnections and Science by Doing have a very strong research basis in terms of what is drawn out of the research and in the ongoing research and evaluation of the programmes. Twenty research reports have been written on PrimaryConnections, looking for evidence of impact that would ensure continued funding. Research has been done on trial teachers and the trialling process, leaders in schools, student learning and an overarching project evaluation. Collaboration with various important groups and committees has had an important impact on the way the project has been taken up in Australia.

DISCUSSION

Question: South Africa experiences similar challenges in primary science education, especially in terms of teacher confidence, knowledge and attitudes. What interventions are recommended to assist in building teacher morale and confidence?
Response: Teachers need to know how to teach the science rather than to know the science. Most primary teachers have a humanities background and dislike science. A different approach was needed to encourage teachers to teach science with confidence, scaffolds were given for them to work with, and the information was given at the point of need. The material includes a CD which gives more information when required. It was difficult to persuade members of the Academy of Science to accept this approach.

Question: What is your opinion on training the trainers as opposed to the programme for training the teachers?
Response: Professional learning is regarded as the most important aspect of what we do as well as the biggest challenge. It has been found that the trainers become so confident that they have been promoted in the education system and no longer teach in the classroom. Nevertheless, this has worked in favour of IBSE, as many of these people have become decision-makers and are prepared to use PrimaryConnections to implement the National Curriculum for primary education. Training workshops are extremely expensive to run in Australia, mainly due to the geography of the country. It would be useful to implement pilot centres.

Question: How does the Australian Academy of Sciences support the two programmes?
Response: The Academy is a non-profit organisation, and it was therefore necessary to obtain funding from the Federal Government. Philanthropy is not directed specifically at the projects. It is likely that the programme may not receive funding from next year, and corporate sponsorship may have to be considered to continue the programmes.

SESSION 4: INQUIRY-BASED SCIENCE EDUCATION: DEMONSTRATIONS

Facilitator: Diane Grayson
University of Pretoria

WESTERN CAPE PRIMARY SCIENCE PROGRAMME (PSP):

Nadiema Gamieldien and Rosemary Thomas
Primary Science Programme

Primary Science Programme (PSP), started in 1984, works with teachers in primary schools from Grade R to Grade 7, in the Western Cape and in other provinces on invitation. The organisation focuses on the teaching of natural sciences, languages, mathematics, and social sciences using an integrated approach. Schools are supported through workshops for teachers, and teachers are supported and guided in the implementation of IBSE in the classroom. PSP's approach is one of hands-on, minds-on, and pen on paper, with literacy integrated in all the lessons. PSP aims to build confident teachers who enjoy and understand what they are teaching so that the lessons will translate to the learners.

The organisation incorporates aspects of indigenous knowledge in its implementation, in response to the curriculum learning outcome around understanding science in the context of South Africa's history and indigenous knowledge and to observe how science links with technology, society and the environment. It is important for learners to understand the importance of the linkages between humankind and their environmental context, a key element in the implementation of the programme.

The presenters demonstrated PSP's integrated approach through activities around natural fibres and indigenous knowledge on natural fibres involving the participants. The demonstration of a typical lesson began by interacting with the participants ('learners') around the variety of traditional practices that people need to sustain themselves. The activities focused on the scientific concepts around three aspects of traditional domestic practices: making clothes, building shelters and making utensils, observing technologies involved, learning science concepts, and the impact of activities on the environment. The properties of materials (different grasses and reeds) were observed and discussed. Questions were posed and knowledge was contributed through this process. The process of photosynthesis was explained, and the products of photosynthesis (glucose and starch) were observed, discussed and questioned to facilitate an understanding of the different chemical substances and their 'chain structures'. Activities carried out by the participants demonstrated that when fibres are woven, knitted or crocheted together, they are strengthened, and utensils and garments can be produced. Communicating a specific scientific or mathematics concept and writing notes about the process was an important aspect of the integrated learning approach.

A further activity was carried out to illustrate the classification of materials made from cellulose fibres, synthetic fibres and animal fibres. The delegates participated in testing the response of various kinds of fabrics to heat, making certain observations and arriving at conclusions through discussion in pairs or groups.

The demonstrations were examples of the typical classroom environment where such lessons would extend over several weeks and involve an expanded process to illustrate a specific scientific concept.

DEMONSTRATION OF LA MAIN À LA PATE

Odile Macchi
French Academy of Sciences

Pierre Lena, one of the architects of the LAMAP programme, explained the purpose of LAMAP in his introduction to the DVD that was shown to illustrate the practical implementation of the LAMAP programme in the typical classroom environment in primary schools in France. Many of the LAMAP documents, CDs and DVDs have been translated into English and are freely available in both French and English.

The DVD was made up of three parts:

- A demonstration of lessons in the classroom
- Discussion by education specialists on the significance of the lessons and the LAMAP approach to teaching
- An explanation by the General Inspector of Primary Schools of the Ministry of Education on the relationship between reading, writing and science.

The fist part of the DVD was shown, which demonstrated the application of LAMAP in several classroom scenarios with different age groups. The various activities focused on the integration of science, mathematics and literacy and the development of knowledge of scientific concepts.

DISCUSSION AND COMMENTS

Comment: The approach allows for flexibility for the teacher and learners in the classroom, accommodating individuals and slow learners.
Comment: The boys seemed to be more vocal and participated more actively in the experiments than the girls.
Comment: It must be kept in mind that girls who are 10 to 12 years old are naturally shy. In this age group, boys would generally be more vocal and confident than the girls. Teachers are not responsible for the non-participation of the girls in the class, but they should be aware of this tendency and ensure that girls participate actively in the group activities.
Comment: The different tendencies of boys and girls at certain ages are taken into account in LAMAP, particularly at secondary school level.

WOMEN IN PHYSICS

Diane Grayson and Mmantsae Diale
University of Pretoria

Statistics reveal that there are very few women in physics compared to the other sciences. Over the last century, only two women were awarded the Nobel Prize for physics, while four women received the award for chemistry and ten for medicine. In 1999, the General Assembly of the International Union of Pure and Applied Physics (IUPAP) formed a working group for women in physics in order to:

- survey the situation for women in physics in IUPAP member countries
- analyse and report results with suggestions on how to improve the situation
- suggest ways that women can become more involved in IUPAP
- report back to the General Assembly in 2002.

It was observed that each country had its own particular circumstances, and the needs in terms of women in physics would therefore differ. In 2005, an organisation called Women in Physics in South Africa (WiPiSA) was launched in South Africa. It is funded by the Department of Science and Technology and administered by the South African Institute of Physics (SAIP). The aims and objectives of WiPiSA, focused on the unique South African context, are:

- to stimulate an interest in physics among girls and women
- to encourage girls and women to study physics
- to encourage and support girls and women to work in physics-related careers
- to assist in removing or overcoming obstacles and barriers for girls and women to study physics and work in physics-related careers
- to attract girls into physics
- to mentor young women in physics
- to obtain baseline information on women in physics in South Africa.

The South African Government has stated that WiPiSA is one of the most successful programmes to highlight women's issues in South Africa. WiPiSA carries out projects in schools to interest girl learners in physics by providing role models. Some of the activities done with groups of girls, based on topics from the curriculum around basic physics concepts, were demonstrated in the workshop and involved the active participation of the attendees.

The first activity was around resistors as a topic that had already been covered in the girls' science classes by WiPiSA. It was decided to introduce the girls to the resistors used in electronics and show them how to make necklaces or bracelets from them. The resistors were colour-coded, indicating their respective values, and the total resistance was calculated according to these codes. The exercise incorporated a number of ways to make science interesting for girls.

A second activity that was carried out with the girl learners was to make a bedside lamp from a plastic bottle, a battery, a length of electric wire with a switch, a light fitting and a light bulb. This was a practical exercise that produced an item that the learners could take home. The relevant physics concepts were experienced and explained after completion of the activity. Working with tools was an important aspect of building the girls' confidence.

A third activity involved making ice-cream using liquid nitrogen, which illustrated the application of physics in food preparation.

DISCUSSION

Question: The Department of Basic Education initiated the project, 'Take a Girl Child to Work Day'.
What is WiPiSA's role in this project?
Response: Grade 8 girls are invited to the physics laboratories at the University of Pretoria where they can see physics in action. This stimulates them to know more about physics.

Comment: There is a lack of communication and lack of media exposure to science issues that inform public opinion. It is important that all learners should do basic science at school level. The affirmative action policy in Uganda that relates to the promotion of girls in science could mean that the quality of women scientists is inferior to that of male scientists. Excellence should remain the primary factor, particularly in developing countries. It would be preferable to award scholarships that would attract quality female scientists.
Response: Women in Physics internationally is very concerned about this issue and would not want to see that the quality of women physicists is inferior to men. There have been three international Women in Physics conferences, and South Africa is hosting the fourth in April 2011. These conferences concentrate on physics as well as on the issues around attracting more women into physics careers.

Question: What funding opportunities are available for girls from poor communities to study physics? Funding is essential in order to encourage girls to continue their studies.
Response: The DST offers bursaries for undergraduate study.
Response: Currently 53 BSc students are funded by the NSTF. Access to the information about bursaries needs to be accessible, and information must be available to all potential students, especially those in rural areas.

SESSION 5: IBSE FOR GIRLS-SOME RESEARCH FINDINGS

Facilitator: Nnenesi Kgabi
Polytechnic of Namibia

HOW TO REACH OUT TO GIRLS, THEIR FAMILIES AND COMMUNITIES TO ATTRACT THEM TO IBSE *(Presentation via Skype)*

Shirley Malcom
American Association for the Advancement of Science

The American Association for the Advancement of Science (AAAS) has a range of programmes that are aimed at improving the quality and access to education in science and engineering; increasing the representation of girls, minorities and persons with disabilities in education in these fields; and increasing the number women in careers in these fields. It was understood early in the process that in order to change the workforce, it was necessary to start early in terms of the type and amount of education in science that girls received.

AAAS has been actively involved in efforts to promote good early experiences in the sciences and to convince people that it was a sound pedagogical strategy to provide hands-on experiences to learners from a very early age. The main idea is to take advantage of the fact that it is natural for humans to explore, to make sense, and to seek patterns through early experiences in their world that convey science. It is interesting to begin to learn more about the way the brain develops in order to understand why experiences are important. Learning is a social activity where small children engage with the adults around them, have a vast interest in the occurrences around them and are very observant about their surroundings. This is one of the reasons why it is important that parents understand that the things they do can make a difference, both positive and negative. Girls can develop the notion from a very young age that doing science or mathematics is not for them, and there is a need to dispel this misconception by showing them the science around them and providing them with images of people who are doing science that matters to the lives of those around them. Attitudes need to be addressed in affirming that science belongs to women and that there is no inherent contradiction between the lives they live and the science they do. Science is already inherent in the lives of their children and their families. Examples of L'Oreal-UNESCO award winners, the Women in Science winners and other similar awards can be used to dispel this notion and affect attitudes towards women in science.

However, practice still needs to be affected. This must begin with the way that teachers are educated and trained from the beginning to prepare them to focus on race and gender inclusion and to provide strategies for them to use examples from the community to introduce science. Teachers also need to be trained to work with families and in communities. The nature of the curriculum would have to explicitly include things that appeal to girls, things that would appeal to boys and things that might be gender neutral, as well as the science within the inquiry experience. The kinds of examples used in hands-on experiences will matter.

Beyond the curriculum, classroom management is important in order to ensure that there are opportunities for girls to be engaged with inquiry experiences. This needs to be monitored, and girls should be encouraged to develop their ideas. Teachers need to ensure that both girls and boys have the opportunity to handle the materials and collect data when working in groups. The encouragement and support given by teachers is crucial in soliciting ideas from students. Allowing for modification and extension of the initial ideas with experience is another strategy that is effective in the classroom with regard to engaging the girls around input.

Possible strategies to improve practice include:
- Have a colleague watch and time the amount of interaction with boys and girls
- Monitor how much time is spent in controlling behaviour versus offering instruction
- Monitor how much time the teacher speaks versus students speaking.

Possible ways to engage parents and communities include:
- Use festivals and fairs to celebrate the role of science and technology
- Engage families in the same types of activities as their children
- Have the learners as explainers, demonstrating to their families what they have come to understand
- Introduce families to college students and working professionals in science and allow for interaction with them that includes aspects of their home and family lives, as well as their professional careers.

DISCUSSION AND COMMENTS

Comment: It is crucial for parents and communities to be involved. Each LAMAP pilot centre is linked to parents' associations and community activities that are relevant to the programme. Their participation reflects positively on the learners.
Response: I am familiar with LAMAP. The basic message of the programme is that the interest and the experiences of the learners are built upon and they are helped to develop the science ways of thinking. It is appropriate for LAMAP to be showcased at this workshop.

Question: It was emphasised that the selection of activities and examples in the classroom are important in IBSE. Communication, family participation and the environment were also stressed. How would this apply to most sub-Sahara African countries, and how could we influence policy-makers to help drive the implementation of IBSE?
Response: My presentation focused on teachers in training to ensure that the next group of teachers is ready to take on IBSE. The only way to start implementing IBSE is with the teachers that are already teaching. This means that they must have these experiences and go through the same kind of inquiry experiences that their students will go through. This may mean that they must work in groups, with a few teachers who are designated to use IBSE, until everyone is comfortable using the method. It may be necessary to have a coach, who will work with them while they test IBSE in the classroom. People who are retired can be used as coaches. This strategy was employed at the teachers' academy for maths and science in Chicago, based on LAMAP principles. This takes time, but the positive experiences in the classroom will reinforce IBSE to the extent that they will not want to return to the old ways of teaching.

Question: IBSE is time-consuming compared to the conventional way of teaching. How is the time factor built in, given the crowded nature of the curriculum?
Response: This issue becomes a reason not to do IBSE. There is the idea that other subjects also need to be taught. However, IBSE involves not only science. Students also talk with one another, collect data, write down their responses and connect the scientific concepts to their lives. Language is learnt, and new words are introduced that are associated with ideas. Other kinds of competences are being reinforced. Research indicates that a high quality, hands-on inquiry-based science programme supports reading and writing.

Question: What is the method of assessment for the IBSE approach?
Response: Assessment is a challenge and it is far simpler to give paper and pencil tests. Many people believe that students ought to be able to respond to these tests but there is the advantage of embedded assessment that is a part of instruction. As the inquiry activities are done, engaging with students in conversation is a form of embedded assessment. Although this is more difficult and more creativity is needed, it is not impossible. The notion of how one assesses is crucial because this will either support inquiry in the classroom or it will drive it out.

Question: Integration of disciplines is an advantage of the inquiry-based approach. Do you think that IBSE promotes an integrated approach to science learning?
Response: It certainly does. The experience leads to other questions, which is the strength of IBSE. It is not limited to a single question. However, this is also a challenge because the teacher would need confidence that the questions may lead to areas where he or she is not an expert. This should not be a threat to the teacher, because IBSE is more about questions than answers. IBSE underscores a very different instruction strategy and conveys a much surer sense of the nature of science.

Question: At what age is it appropriate to introduce inquiry-based science? Should students be able to read and write?
Response: IBSE should be introduced at pre-school level, because the nature of pre-school instruction is consistent with inquiry-based science. There are many opportunities to engage learners.

Question: You mentioned that curriculum examples should appeal to girls. Can you give such an example?
Response: Examples should be taken from the regular lives of the girls you are dealing with. This may require asking the girls what they are interested in and what they do and build from their responses. Not

every girl is engaged in the same activities. It is the role of the teacher to see where the entry point may be for this engagement.

Comments: This workshop is an opportunity to do something that is transformative, and this is very important. AAAS stands ready to assist where we can in order to make a difference in terms of rethinking the strategies to engage learners and students from different kinds of backgrounds. I firmly believe that this is an exciting instructional strategy and that it has the potential to be totally transformative, not only with regard to science, but with regard to the way that the science integrates with many other fields.

In summary, Dr Malcom emphasised:
- the selection of activities and examples
- the issue of communication
- the use of resources such as time
- family and community participation, the environment and the relevance of science in the learner's life
- the process should start with the existing teachers.

DISCUSSION

It is anticipated that the policy-makers booklet produced as a result of the workshop would lead to implementation of IBSE in sub-Saharan Africa. Participants' suggestions of what should be included in the booklet included:
- The outcomes-based approach was not implemented in teacher training. IBSE must be introduced at teacher training level to prepare new teachers. Simultaneously, in-service teachers need to be trained in IBSE. Government would be required to earmark funds for this training.
- It is evident that IBSE cuts across all cultures. The principles of national education programmes in South Africa acknowledge IBSE. However, the barrier to the successful implementation of IBSE would be family background and the lack of participation of parents, who would not be able to connect with science concepts.
- Content coverage and science processes could be the focus of IBSE. It is possible to include IBSE in the training of teachers. Departmental officials should have a clear understanding of this approach.
- Uganda has tried to implement IBSE, starting with pilot centres at primary level. Our experience is that it works well, but the schools prefer to align themselves to the curriculum laid down by the Ministry of Education. Implementation of IBSE would require much lobbying and redesigning of the curriculum.
- In terms of the professional development of teachers, agreement to implement IBSE must be coupled with a sound conceptual understanding of science. The goal of IBSE is to have activities that learners can follow using practical examples and experiences as well as being able to develop their understanding of the science concepts. This requires that the teachers are skilled in facilitating learners' questions and discussion that begin in the classroom and in putting forward their evidence. Substantial training and development of teachers is necessary if IBSE is to be successful. Much practice and support are needed in order to build teacher's confidence. Pilot centres are one way of helping teachers to develop confidence in implementing IBSE.
- The assessment and content coverage aspects of IBSE require further investigation and discussion.
- IBSE does not necessarily mean that less content will be covered. It does require that lessons are carefully structured with much preparation around the concepts to be covered and the reasoning skills that are to be developed.
- What other teachers need to be involved in creating the relational aspects of IBSE? If other subjects outside the science scope are included, much more can be achieved in terms of content coverage. Science Academies are in a strong position to lobby and advise policy-makers with regard to IBSE. They would be able to make a case for changing curriculum in their countries. National Science Academies would therefore be strong champions of IBSE in terms of involving policy-makers.
- Young graduates are involved as coaches in schools for the LAMAP programme. Redesigning curricula requires proof that the alternative approach is successful. The implementation of IBSE needs to be slow and involve as many people as possible.
- An evaluation strategy would need to be in place to ensure that the implementation of IBSE is effective in the pilot schools.

The general discussions were summarised as follows:

The group agreed to recommend IBSE but proposed that certain issues around the implementation of IBSE need to be clarified and discussed further. Redesigning the curriculum is necessary. Continuous assessment and content coverage issues need to be considered, particularly in the context of the requirements of the Department of Basic Education. The evaluation of IBSE in pilot schools needs to be done to monitor the effectiveness of the programme.

FACILITATED DISCUSSION ON AMERICAN ASSOCIATION OF UNIVERSITY WOMEN (AAUW) REPORT, 'WHY SO FEW?' (WOMEN IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS)

Mmantsae Diale
University of Pretoria

AAUW was selected by the US National Science Foundation to conduct a study on the under-representation of women in science, technology, engineering and mathematics. The report was distributed to all participants of this workshop in preparation for this discussion.

General

When discussing education and policy issues, working with families, the study should include the social sciences. Participants were cautioned against isolation of the STEM issue without including social sciences issues. Narrowing the definition of 'science' is limiting. Several Academies of Science around the world are moving towards 'Academies of Sciences and Humanities', especially in Europe. This has been seen to be extremely beneficial.

Beliefs about intelligence

It was clarified that the report states that it has been demonstrated that girls are less capable in the area of spatial orientation, rather than in mathematics generally. However, there is the belief that girls are less able than boys.

Cognitive sex differences

- People may believe that there are cognitive differences between the sexes. This belief tends to be perpetuated in classrooms and in homes, resulting in a self-fulfilling prophecy. Generalisations should not be made, as individuals have differing degrees of capabilities.
- The difference between 'sex' and 'gender' should be clarified. While 'sex' implies biology, 'gender' implies not only biology but also the social behaviour and identity of a person.
- There is no difference in overall ability in mathematics between girls and boys. Cognitive ability does not depend on gender.

'Just not interested'

- Studies have been done about the context of physics problems (guns, bullets, canons) and the effect that these can have on girls and young women. The physics problems are not interesting to girls and tend to put them off physics. When the context is neutral or female-friendly, it is more effective in attracting girls to physics.
- Girls often do not become interested in physics because they do not take the courses.
- The scientific community is male-dominated and can therefore operate according to the rules of engagement of men, which can be hostile to women.
- Laboratories are cold and impersonal. There is a belief that physics is not a glamorous career path. There is a need to use language that is attractive to women. Girls need to see that science relates to everyday-life situations. Girls like to choose careers that make a difference to other people's lives and serve others. It is hard to see now abstract physics and mathematics can serve others through life-changing research. Projects are needed that have a social function in order to attract girls.
- There is a need to communicate the science that is being done (even the small projects) and make it sound important.
- The South African National Curriculum has captured the degree to which gender, poverty and age may influence learners in their schooling. The policy already exists, but teachers need to ensure that it is put into practice.

Workplace environment, bias and family responsibilities

- The report states numerous issues around the workplace, bias and family responsibilities that discourage women from embarking on a scientific career. Much still needs to be done to make the workplace conducive to women scientists.
- Women scientists tend to have personalities that allow them to survive in the hostile environment of science. Other women need to be empowered to do likewise, and young girls need to be taught how to

assert themselves in the science environment. Girls need to be trained to become more confident in a male-dominant environment. Teachers must be aware of the tendency to stereotype genders. Families are responsible for creating a confident personality to supplement what teachers do at school.

- It has been found that it is often women who oppress other women in the workplace. There is often insecurity among the women who hold senior positions.
- Setting up nursery schools on school premises may encourage girls who have to take care of siblings or their own children to continue attending school.
- Boys need to be taught at a very young age that the family is not only the responsibility of girls and that boys have an equal role to play.
- Many women and men are driven to succeed because of their family responsibilities. Families should not be seen as a drawback to success.
- Mechanisms are available in South Africa to address gender issues.

Prof Diale summarised the discussions as follows:
The following issues need to be addressed in order to attract girls to science:

- The girl environment and context of teaching
- issues related to culture and perceptions
- lack of exposure of girls to careers in science
- image portrayed by the scientific community in terms of women in science
- general perceptions about scientific careers.

The following suggestions emanated from the discussions:

- IBSE should be piloted and evaluated prior to broader implementation
- Teachers should be trained and exposed to hands-on activities
- The curricula should be redesigned around the method used to present the existing subjects and content and take into account different ways of assessment.
- A mindshift is needed by all involved in IBSE
- Methods of assessment need to be discussed.

SESSION 6: INQUIRY-BASED SCIENCE EDUCATION: IMPLEMENTATION AND RECOMMENDATIONS:

Facilitator: Sophia Huyer
Third World Organisation of Women in Science

PRIMARYCONNECTIONS: LINKING SCIENCE WITH LITERATURE:
Shelley Peers
Australian Academy of Sciences

New ways of teaching science are needed because the old ways, which tell learners what is right and expect them to tell us back, are not working. PrimaryConnections is an initiative to improve the quality of science education for primary students, engaging students and building teachers' confidence. PrimaryConnections is a multi-pronged IBSE approach with scaffolds and structures that are built around it to help teachers. It is based on research, and the learning demand of science concepts has been taken into consideration. Most curricula are written by people who know science well and who to tend to break it down into small sections that are distributed throughout the years of primary education. Although the curriculum appears to build a logical structure, research has shown that learners cannot learn in that order and PrimaryConnections teaching material tries to address new ways of teaching science.

Research has shown that professional learning or giving teachers already written units have an impact, but when these two aspects are joined, there is a multiplier effect in changing teacher practice. PrimaryConnections builds both of these aspects together and believes that school science is about helping learners to learn. Eight key elements for quality school science are:
- scientific methods and critical testing
- the role of creativity in science
- historical development of scientific knowledge
- science and questioning
- the diversity of scientific thinking
- the relationship between science and certainty
- the role of hypothesis and prediction
- the role of competition and collaboration.

The five underpinning principles of the PrimaryConnections inquiry approach are: 5Es teaching and learning model, embedded assessment, linking science with literacy (and numeracy), student-planned investigations and cooperative learning.

5Es teaching and learning model
It is important to start with engaging around a reason to know something. The activity does not teach, nor does it prove the concept. It is necessary to engage the learner from a constructivist perspective, and the 5Es structure is used for that purpose. The 5Es framework (Figure 1 below) is aimed at supporting teachers and building their confidence.

Phase	Focus	Assessment
ENGAGE	Engage students and elicit prior knowledge	Diagnostic assessment
EXPLORE	Provide hands-on experience of the phenomenon	Formative assessment (feedback to students)
EXPLAIN	Develop scientific explanations for observations and represent developing conceptual understanding. Consider current scientific explanations	Formative assessment (feedback to students)
ELABORATE	Extend understanding to a new context or make connections to additional concepts through a student-planned investigation	Summative assessment of the investigating outcomes
EVALUATE	Students re-represent their understanding and reflect on their learning journey and teachers collect evidence about the achievement of outcomes	Summative assessment of the conceptual outcomes

Figure 1: PrimaryConnections' 5Es framework

Embedded assessment

The most important aspect of assessment is to establish what should be assessed and why it should be assessed. The nature of science that PrimaryConnections tries to encompass is scientific literacy, not just scientific facts. The scientific facts underpin conceptual understanding. Scientific literacy should be assessed. Assessment is integrated with teaching and learning. The types of assessment are:

- diagnostic assessment *for* learning: reveals students' prior knowledge for planning following lessons
- formative assessment *of* learning: enhances learning through giving feedback
- summative assessment *as* learning: from the work samples that are generated by students.

If the focus is on learning and teacher capacity to enable this, it is necessary to observe how often students do tests, what is tested and what is done with the information and feedback. Assessment must serve to help students to improve their learning. Research conducted showed that only one third of the trial schools in Australia reported on student learning to parents, and that parents tend to be more concerned about the happiness of their learners at school and whether they can read and write.

One PrimaryConnections unit takes about ten weeks to complete. Teachers who are not trained in science are supported by the PrimaryConnections material, which gives a conceptual understanding that is needed for each unit as well as information that the teacher should know in order to teach the unit, in a language that is easy to understand. CDs that give in-depth information about the science content knowledge are included with the material for each unit. Holistic learning (not specific subjects) is taught at primary school level in Australia. A wide range of subjects are embedded in the programme, and substantial content is covered through integrated learning. However, the aim of IBSE is not to cover large volumes of content but rather to achieve a conceptual depth that promotes understanding and knowledge for the learner.

Linking science with literacy

Language is not simply part of science, but an 'essential constitutive element' of science. In order for students to make a claim and state the evidence and their reasoning, they need to be comfortable with the scientific language, and need to be specifically taught this. PrimaryConnections makes links between science experiences and the way understanding can be communicated, such as creating a labelled diagram or recording detailed observations in a science journal. PrimaryConnections uses the phrase 'literacies of science', in referring to particular language practices, processes and products that students learn about and use to reason, represent and communicate their understanding of science concepts and processes. Through the process of talking about what they do or drawing about it, learners start to think about science concepts, which is a very important part of IBSE.

Students use their everyday experiences to learn the 'literacies of science'. Research has shown that literacy skills do not develop in isolation from a context. Science provides an authentic, meaningful context for literacy (and numeracy) learning. The PrimaryConnections 'TWLH chart' helps focus on:

- T: what we think we know (based on constructivist principle)
- W: what we want to learn
- L: what we learned
- H: how we know (the point of argumentation and results in intellectual engagement and conceptual development).

Student-planned investigations

A scaffold for teachers and students to use in the investigation process was demonstrated to participants.

Students made paper 'spinners' or 'helicopters' and allowed them to drop. This led to a question asked by the teacher around the things (variables) that would effect how fast the spinners fell, and the students' responses were written on Post-it notes. The next step was to test these variables against the 'time to fall'. A 'variables grid' or table was drawn up with the 'time to fall' in the middle block and the variables (on Post-it notes) in each of the surrounding blocks. A 'CMS' table (something must Change, something must be Measured and everything else must be kept the Same) was drawn up from the variables grid to illustrate that a fair test was done. The CMS table was transferred onto the students' investigation plan. This method, called 'Post-it Note' is used in all parts of the world and facilitates simultaneous or consequential investigations taking place in the classroom.

One of the main reasons for argumentation is for learners to articulate and communicate the data they have collected, where it has come from, and whether or not it is believable.

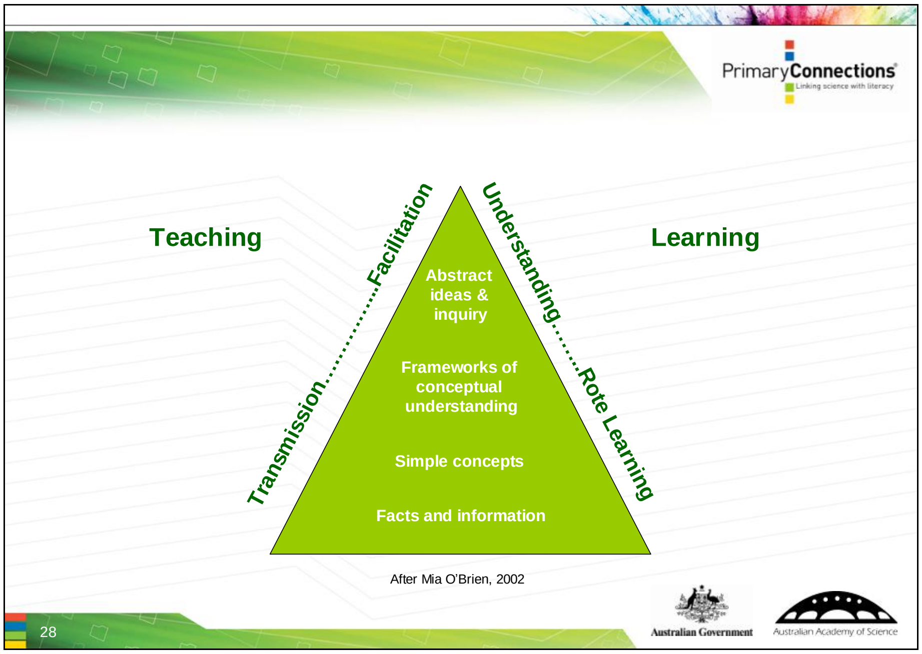

Figure 2: Links between teaching and learning

If the teacher has a sense that teaching is about telling and learning is about remembering, their pedagogy will be at the bottom end of the triangle. As the pedagogy moves up to facilitation about abstract ideas and real inquiry, the students will move from rote learning to developing understanding (Figure 2 above). The entire aspect of covering curriculum content is addressed in the graphic presentation of the conceptions of teaching and learning. Teachers have to move from novice, to competent, to expert and are shown how to do so by referring to the continuum for teaching science which involves:

- Activity-based work: Fun, hands-on activities designed to motivate students and keep them physically engaged
- Investigation-based work: Abilities to engage in inquiry, ask testable questions and design fair tests, focused on collecting data
- Evidence-based work: Need to support claims with evidence; evidence is not questioned in terms of quality, coherence etc.
- Argument-based work: Argument construction is central; coordinating evidence and claims is viewed as important; and alternatives are considered.

PrimaryConnections project design, professional learning design and curriculum resources design
The design structure uses the five underpinning principles to build the project, and the project brief explains the underpinning principles. Each design has sections on the rationale, the principles and the features. An IBSE approach in sub-Saharan Africa would require that the educational design structure is given serious consideration. The approach needs to be achievable by all teachers, scalable (able to have large-scale uptake) and sustainable in order to bring about reform.

Project design
The project is designed around the following elements:

- Rationale for project
    - Constructivist theories and inquiry-based approaches
    - The most effective way to implement reform is to enable all current (and pre-service) teachers
    - The approach must be achievable in a primary classroom by a novice teacher

    - PrimaryConnections is a way of thinking about teaching and learning science. It is an approach, not just a set of books or a set of workshops
- Design principles for project
    - reform orientation
    - focus on the teacher
    - scalable (able to have large scale uptake)
    - sustainable
    - based on research
- Design features for project
    - Two-pronged approach: professional learning and curriculum resources
    - informed by ongoing trialling and evaluation

Professional learning model design

The professional learning model is shown in Figure 3 below and the main elements are as follows:

- Underpinning philosophies for professional learning
    - Constructivist theories
    - Positive approach, not a deficit model
- Design principles for professional learning
    - Not once-off workshops but a programme to build competence
    - Informed by pedagogical principles
    - Takes account of the stages of concern for teachers implementing an innovation
    - Based on research
- Design features for professional learning
    - Variety of staged professional learning training
    - 24 facilitation tools and techniques
    - A resource of a series of prepared workshops that can be tailored to context by facilitators
    - Provide PowerPoint slides on CDs
    - Informed by ongoing trialling and evaluation.

Curriculum resource design

The curriculum resource design builds on the following elements:

- Underpinning philosophies for curriculum resources
    - Constructivist theories
    - Inquiry-based investigative approach
    - Linking science with literacy
    - PrimaryConnections 5Es teaching and learning model
    - Co-operative/collaborative learning
- Design principles for curriculum resources
    - Curriculum replacement strategy
    - Should be do-able by novice teacher
    - Resources teach teachers how to teach science (educative curriculum materials)
    - Scalable and suitable for uptake Australia-wide
    - Based on research
    - Informed by ongoing trialling and evaluation
- Design features for curriculum resources
    - Aligns with teacher core business
    - Reflects the nature of science
    - Builds student capacity for inquiry
    - Literacy focuses and 'literacies of science'
    - TWLH chart
    - Interesting and hands-on activities, Student work samples
    - Cross curricular approach to planning, inclusion of curriculum links
    - Do-able within one term (ten weeks of instruction).

Professional learning facilitators (PLFs) are trained for three full days in-house, with the aim that they will in turn train teachers in their own school and other schools. Two days of training is done for Curriculum

Leaders, with the expectation that they will tell at least one other teacher what they have learnt. It was found that these key people became science coordinators in their school. Curriculum resources and professional learning resources were necessary as a scaffold. Master facilitators are trained to replicate in-house training staff so that more PLFs and Curriculum Leaders can be trained. Between 2006 and 2010, 125 tertiary facilitators (university lecturers), over 1000 Curriculum Leaders and 500 PLFs have been trained in 6000 workshops conducted by Academy staff and trained facilitators. Most of the training takes place during school time under the system of 'teacher release', which is made possible by Federal Government funding.

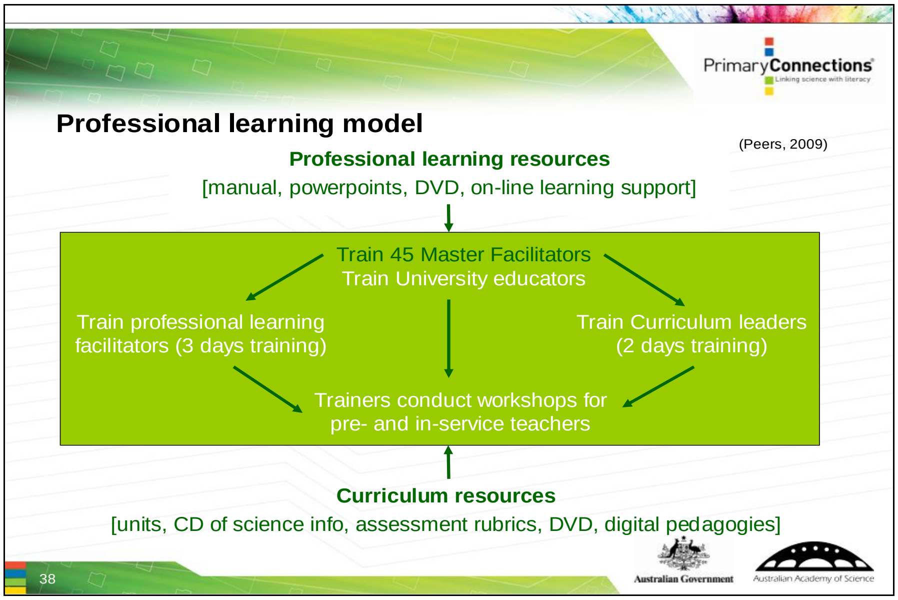

Figure 3: Professional learning model used in Australia

Sub-Saharan Africa may require a model that has different trigger points. The challenge lies in the need for South Africa to find the trigger points as well as the answers applicable to local circumstances.

Research findings

Ongoing research is done in order to assess whether PrimaryConnections is making a difference. To date, 20 research reports have been undertaken to establish the evidence of impact that would ensure continued funding of the programme. The research findings are available on the PrimaryConnections website (http://www.science.org.au/primaryconnections/) .

Conclusion

A value voting exercise was done by posing the following questions to the workshop participants:

- On a scale of 0 to 100, how important is it to you to have IBSE promoted/supported/implemented in South Africa at this point in time?
- On a scale of 0 to 100, how well is IBSE understood by those in South Africa who have the power to make decisions about the implementation of a primary science curriculum?

The answers to these questions were written on pink and yellow Post-it notes respectively. The two groups of notes were placed on the wall, sorted from highest (100%) to lowest (0%). The responses gave the view of all the delegates and a dichotomy between the two sets of responses was evident. The reasons for this need to be understood in order to work together and to move towards the implementation of IBSE.

Delegates were also asked to consider the answers to the following questions:

- What are the three biggest challenges facing South Africa in primary science education?
- What one thing can you do in the next two weeks to make a difference to the teaching of primary science in South Africa?

KEY RECOMMENDATIONS REGARDING IBSE FROM THE WORKSHOP TO POLICY-MAKERS IN SUB-SAHARAN AFRICA

Sophia Huyer
Third World Organisation for Women in Science

Participants' contributions to the key recommendations from the workshop were consolidated as follows:

Challenges in adopting and implementing IBSE in sub-Saharan Africa

1. *Challenges for Teachers, teaching, and on teacher training*
    - Teacher training does not train teachers to address current issues
    - Student–teacher ratio in schools make it difficult to give individualised attention to every student
    - Not all policy-makers are aware of IBSE strategies and the value of IBSE:
        - Most countries' assessment standards do not include aspects of IBSE
        - Interpretation of education policies by educators is hampered by lack of understanding of IBSE approaches
    - Lack of in-depth content knowledge of teachers and lack of access to quality resources (i.e. difficulties with internet access) and a lack of science background among teachers
    - Teacher training in general is inadequate with training needs being less specific and less focused
    - The rotation of teachers through subject areas leads to a loss of trained teachers
    - There is a lack of time for in-service training for teachers
    - Teachers are overloaded with a range of responsibilities
    - Examples and equipment that can be used in the classroom are inadequate

2. *Implementation challenges for IBSE*
    - The student–teacher ratio does not allow for students to be provided with individualised attention
    - Integration of IBSE in multi-graded classes can pose a challenge
    - The multilingual nature of most classrooms can pose a problem when implementing the approach
    - Language constraints by both learners and teachers
    - Current focus of the curriculum is on exam training rather than knowledge generation
    - School timetables are not flexible to the needs of IBSE
    - Natural sciences are not given sufficient teaching time on school timetables (the argument needs to be made that IBSE takes time but teaches multiple skills and is not confined to the natural sciences)
    - Attitudes towards change among teachers, learners and policy-makers are lacking
    - Inadequate concrete follow up of action points after deliberations on IBSE at various fora
    - Misconceptions relating to IBSE: It should be considered as a powerful strategy to be infused in the existing curricula
    - Local research on implementing IBSE approaches in the sub-Saharan Africa classroom is needed
    - Current classroom culture and climate does not support IBSE strategies

3. *Challenges for the education system*
    - Inadequate funding for human resources, training, and materials for the implementation of IBSE
    - Lack of support from government and education line ministries on implementation of IBSE approaches
    - Lack of access to basic textbooks
    - Disconnect between practitioners, educators and policy-makers who need to be involved in developing education curriculums and their resources
    - A lack of alignment of curricular changes with the assessment process, which requires a partnership between implementers, educators, policy-makers and national examination councils
    - Poor understanding by policy-makers of how to achieve educational reform
    - A lack of understanding that science supports any campaigns aimed at math and language literacy
    - Sustainability of science projects is lacking
    - Lack of efficient and effective management of schools
    - Money tends to be spent on documentation and not on implementation of new approaches

- Weariness concerning educational changes in the system especially where a country's education system has undergone several reforms

4. *Challenges related to communities and families*
    - Parents do not understand the importance of mathematics and sciences
    - Educators are not respected in the community, and there are perceptions that teachers are not sufficiently qualified and that teaching is not of an acceptable quality.
    - Learners do not take responsibility for their own education
    - Cultural and socialisation dimensions affect how IBSE is conceptualised and understood, which could mean that the value of IBSE in education is underestimated.

5. *Challenges for South Africa*
    - Foetal alcohol syndrome and drug abuse
    - Learner behavioural problems stemming from societal issues

6. *Challenges for the girl child*
    - Poverty
    - Social and cultural factors, which restrict girls' entry into science subjects
    - Traditional expectations that lead to girls being socialised into gender specific role, and that inhibit progression into science education and careers
    - General perceptions that girls lack abilities in areas of science and technology
    - Lack of science role models and mentors in families and the society at large
    - Lack of motivation and encouragement from school, family and community
    - Factors such as infrastructure and facilities of schools that are not female friendly
    - Policy of exclusion
    - Social factors including early pregnancies at a young age
    - Restrictive education policies that do not encourage girls and their families to enrol in school education e.g. lack of free primary education
    - Lack of career guidance that informs girls of science-related careers
    - Girls tend to lose interest in science as they enter adolescence.
    - Science is not seen as appropriate for women in terms of field studies and the career choices it offers
    - Examples and pictures used in science textbooks are not appealing or interesting to girls.

General recommendations on the way forward in implementing IBSE in sub-Saharan Africa

1. The workshop participants agreed that it is appropriate and desirable to integrate IBSE approaches in science classrooms in sub-Saharan Africa at all levels, starting from pre-school. IBSE cuts across cultures and is aligned to the national education strategy.
2. Work needs to be done to educate policy- and decision-makers about the value and importance of IBSE for education in sub-Saharan Africa and how to implement IBSE approaches.
3. An analysis and customisation of LAMAP, PrimaryConnections and other IBSE approaches needs to be undertaken for the Sub-Saharan Africa region, taking into account culture, context and diversity.
4. There is need to undertake a gender analysis or gender layer on IBSE in the region, introducing issues such as:
    - Teacher interaction with students
    - Classroom management strategies
    - Classroom engagement
    - Gender interactions in small groups
    - Different conceptions about mathematics and sciences abilities held by girls, boys and parents (e.g. growth mindset)
    - Strategies to improve practice
5. Pilot workshops should be held with teachers on each IBSE approach, including follow-up support, resources and training of trainers.
6. Science modules in educational curricula should be introduced at earlier levels of primary school.
7. Academics and educators should be involved in policy-making processes on education
8. An appropriate argument for the value of using IBSE approaches needs to be developed.

9. Experiences of other countries in implementing IBSE in different contexts should be shared.

Action recommendations

1. *Preparing teachers*

   The teacher is the starting point for the implementation of IBSE:
   - There is a need for implementation of IBSE in teacher training colleges
   - Money needs to be invested in training teachers on the IBSE approach
   - Teaching resources need to be provided, as well as training and implementation support to ensure sustainability of implementation

2. *Curricular reform and integration*
   - IBSE needs to be embedded in the education curricula
   - There must be a clear message that IBSE is not a single separate subject but combines a number of subjects
   - IBSE needs to be used beyond the primary school level and coordinated among the various levels of science education
   - There is need to strengthen the current curricula using IBSE approaches:
     - identify and use modules that fit existing curricular requirements
     - align available IBSE modules with curriculum guidelines (or vice versa)
     - train teachers in using the modules
     - establish a mechanism for providing coaching to teachers by scientists and experts
   - IBSE modules can be integrated into the current curriculum as they cover the required topics:
     - Work with existing national resources and teachers already developing these approaches using local examples
     - IBSE is considered a powerful strategy to be infused in existing curricula
     - Integrate IBSE into the curricula of teaching colleges.
   - Collaboration of different learning areas and educators in teaching similar and coordinated topics
   - Policy-makers in different government departments should collaborate and coordinate related subjects.
   - Disconnect between practitioners, educators and policy-makers who need to be involved in the development of the curriculum should be addressed
   - Need to align curricular changes with the assessment process: partnership between implementers, educators, policy-makers and national examination councils.

3. *Modalities for implementing IBSE for girls*
   - Implement national pilot workshops with teachers from the country, who will become trainers in IBSE for their area.
   - Need for modules and toolkits for teachers
   - Train teachers in facilitation and moderation of discussion among students
   - Work with teachers to educate them and provide methodologies for including girls equally in science education (i.e. classroom management practices)
   - Recognition of issues
   - Specific integration of gender into the curriculum, including monitoring of implementation
   - Campaigns geared towards parents, schools, government and the society at large, on implementing IBSE should be encouraged
   - Mechanisms for girls’ career guidance are needed
   - Programmes of role models for girls, bringing successful women scientists into classrooms should be implemented
   - Focus on campaigns such as ‘Take a Girl Child to Work’ day should be encouraged and supported

4. *Involvement of parents and communities*

   There is a need to involve parents in implementing IBSE and especially in connecting learners to science concepts, which is a challenge, and to encourage their girl children to be confident in pursuing science education and careers. This should be done through:
   - Working with the relevant ministries or departents concerned with women, children and people with disabilities in this area

- Targeting families and parents through community activities
- Addressing the issues around the encouragement of gender specific roles for men and women
- Focusing on the process of asking questions, the inquiry process is a starting place, teachers can learn this despite their educational background
- The Context/environment in which a learner is experiencing knowledge creation should form part of the process
- Culture, societal and family attitudes shoudl be addressed collectively
- Families, communities and the society should create apportunities where girls are exposed to activities that encourage the process of IBSE
- The importance of role models and mentors for the girl child should be emphasized

5. *Teacher support*
    - Develop teacher support booklets and materials
    - Topic booklets to be used by learners, supported by CDs for teachers
    - Classroom support alongside the teacher in the classroom in the form of coaching

6. *Context of IBSE*
    There is a need to couple IBSE with sound conceptual understanding of science:
    - Teachers need to be able to facilitate questions from learners
    - Support teachers with concept training and information as they learn and teach the modules, i.e. through coaching, answering questions, access to training in scientific concepts, sufficient scientific knowledge

7. *Assessment and content coverage*
    - While IBSE can and does cover prescribed curriculum guidelines, often in more depth, there is a need to develop evaluation and assessment processes for IBSE learning results, which will fit with the national assessment requirements and guidelines.
    - An African-based website should be established to provide links to LAMAP, PrimaryConnections and other IBSE resources, as well as to gender and science education resources
    -

8. *Role of Science Academies*
    - Greater involvement of science academies in encouraging the adoption of the IBSE approach
    - Involvement of science associations
    - Science academies should lobby governments and provide expert advice on IBSE and educational approaches

CLOSURE

Dr Huyer mentioned that TWOWS was willing to provide any supportive networks that may assist in expanding IBSE for girls in the region through working with NASAC and ASSAf. The discussions at this workshop provided a solid base for this interesting initiative to move forward into the region.

Ms Olang summarised the various sessions, highlighting several presentations and activities of the workshop. There was general consensus by all the delegates that the workshop had been a worthwhile experience, where valuable exchange of ideas and interesting and engaging discussions had taken place. Sincere gratitude was conveyed to the ASSAf team for their excellent organisation and support of the event. TWOWS, represented by Dr Huyer, was thanked for assisting with the articulation of the recommendations for the policy-makers booklet. The participants were thanked for having made the time to attend the workshop and for their contribution to the success of the workshop through their presentations and discussions.

Dr Taole extended gratitude on behalf of ASSAf to their partners, the presenters, representatives of other Science Academies and all participants.

The workshop adjourned at 13:40.

APPENDIX A: ATTENDANCE

NAME	ORGANISATION
Conrad Starr	Northern Cape Education Department
Denicia Myburgh	Northern Cape Education Department
Diane Grayson	University of Pretoria
Eliezer Manguelle-Dicoum	Cameroon Academy of Science
Geetha Chacko	Eastern Cape Education Department
Heather Erasmus	Write Connection CC (Scribe)
Hester Kriel	PMG Education
Jacqueline Olang	Network of African Science Academies (NASAC)
Jansie Niehaus	National Science and Technology Forum (NSTF)
Jeanine Mwambakana	Tshwane University of Technology
Jennifer Thomson	University of Cape Town
Jill Farrant	University of Cape Town
Maria Kekana	Mpumalanga Education Department
Mary-Grace Villanueva	CERTI, Nelson Mandela Metropolitan University
Mmantsae Diale	University of Pretoria
Mutheu Ngila	ASSAf
Nadiema Gamieldien	Primary Science Projects
Nnenesi Kgabi	Polytechnic of Namibia
Nthabiseng Taole	ASSAf
Odile Macchi	French Academy of Science
Paul Nampala	Uganda Academy of Science
Paul Webb	CERTI, Nelson Mandela Metropolitan University
Rebecca Mhlongo	University of Limpopo
Roseanne Diab	ASSAf
Rosemary Thomas	Primary Science Projects
Shelley Peers	Australian Academy of Science
Shirley Malcolm	American Association for the Advancement of Science (AAAS)
Sibusiso Moyo	Durban University of Technology
Sophia Huyer	Third World Organisation for Women in Science (TWOWS)
Steve Maletsoa	North West Education Department
Xola Mati	ASSAf
Zama Mkhize	KwaZulu-Natal Department of Education
Zuki Mpiyakhe	ASSAf

APPENDIX B: ACRONYMS

5Es Framework	Engage, explore, explain, elaborate, evaluate
AAAS	American Association for the Advancement of Science
AAUW	American Association of University Women
ASSAf	Academy of Science of South Africa
BSc	Bachelor of Science
CD	Compact disc
CMS	Something must Change, something must be Measured and everything else must be kept the Same
DST	Department of Science and Technology
DVD	Digital video disc
EFA	Education for All
EU	European Union
FAWE	Forum for African Women Educationists
IANAS	Inter-American network of Academies of Science
IAP	InterAcademy Panel
IBSE	Inquiry-based science education
IUPAP	International Union of Pure and Applied Physics
LAMAP	La Main à La Pate
MDG	Millennium Development Goals
NASAC	Network of African Science Academies
NSEF	National Scholarly Editors' Forum
NSTF	National Science and Technology Forum
PFF	Professional learning facilitators
PhD	Doctor of Philosophy
PISA	Programme for International Student Assessment
PSP	Primary Science Programme
SAIP	South African Institute of Physics
SciELO	Scientific Electronic Library Online
STEM	Science, technology, engineering and mathematics
TWAS	Academy of Sciences for the Third World
TWOWS	Third World Organisation for Women in Science
UNCSTD	United Nations Commission on Science and Technology for Development
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UPE	Universal primary education
USA	United States of America
WiPiSA	Women in Physics in South Africa