

***Inquiry-Based Science Education:***  
*Increasing Participation of Girls in Science in sub-Saharan Africa*

Policy-makers' Booklet



Applying scientific thinking  
in the service of society



*"If a child can't learn the way we teach,  
maybe we should teach the way they learn."*

**Igrecio Estrada**

*The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996 in the presence of then President Nelson Mandela, the Patron of the launch of the Academy. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science for the benefit of society, with a mandate encompassing all fields of scientific enquiry in a seamless way, and including in its ranks the full diversity of South Africa's distinguished scientists. The Parliament of South Africa passed the Academy of Science of South Africa Act (Act 67 in 2001) which came into operation on 15 May 2002. This has made ASSAf the official Academy of Science of South Africa, recognised by government and representing South Africa in the international community of science academies.*

## FOREWORD



This policy-makers' booklet aims to provide information to policy-makers in sub-Saharan Africa on Inquiry-Based Science Education (IBSE), with a specific focus on the key role that IBSE can play in increasing the participation of girls in science and mathematics.

Primary education enrolment ratios in sub-Saharan Africa are the lowest in the world with fewer girls accessing primary education. As a result fewer girls take science and mathematics as school subjects. This finding necessitates an exploration of different approaches that can be used to attract and retain girls in science and mathematics subjects from a young age.

The booklet recognises the importance of IBSE in encouraging girls to participate in science and mathematics subjects at the primary school level. It provides recommendations to policy-makers on how to support IBSE implementation on the continent. The key recommendation relates to the integration of IBSE into the school curricula, and the need for policy-makers to support pilot projects introducing IBSE into schools.

Modern science academies recognise, support and promote excellence in scientific research performed by scientists who are citizens of a nation; promote contact among scientists and the global scientific community; strengthen the global position and role of scientific research performed by scientists; provide evidence-based scientific advice to government; and increase public awareness of science in a nation.

Given their role regarding the promotion of science education, and providing advice to their governments, academies in sub-Saharan Africa are well placed to promote IBSE. There is a need for academies on the African continent to work collaboratively in advising their governments on the importance and value of IBSE for girls. The booklet encourages science academies to provide evidence-based policy advice on IBSE – its features, successful contextual implementation, advantages and disadvantages; and to disseminate these messages widely.

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## KEY MESSAGES FOR POLICY-MAKERS

Policy-makers should **endorse the integration of IBSE** into the school curricula, and **support pilot projects** to introduce IBSE into schools.

Policy-makers should **lobby for implementation of IBSE in training institutions**, and **approve financial and other resources** for developing teachers on IBSE.

Policy-makers should **lobby for gender mainstreaming** in science and mathematics teaching, **advocate increased career guidance** for girls on science careers, and **encourage implementation of role model and mentoring programmes** aimed at girls.



**IBSE workshop participants**

## INTRODUCTION

This policy-makers' booklet is a joint project of the Academy of Science of South Africa (ASSAf), the Network of African Science Academies (NASAC), the Organisation of Women Scientists for the Developing World (OWSDW) and the Gender Advisory Board of the United Nations Commission on Science and Technology for Development (UNCSTD). Funding was provided by the IAP, the global network of science academies.

Science academies have a mandate to provide evidence-based policy advice to government and society. They also have the ability to network and bring together experts from a wide range of fields. As a precursor to compiling this booklet, the partners hosted a workshop on Inquiry-Based Science Education (IBSE) for Girls. Experts from France, Australia, Cameroon, Uganda and South Africa were invited to share information on IBSE, look at ways to encourage girls and young women to enter into science at school, pursue science careers, and interventions that could be introduced to nurture girls in science education.

The information presented in this policy-makers' booklet is a synthesis and summary of the workshop participants' deliberations on IBSE, science education for girls and the way forward in encouraging girls' participation in science education.

Access to basic quality education for most of sub-Saharan Africa's children remains a distant reality, with the majority of children out of school being girls. Educating girls in sub-Saharan Africa is critical to achieving all the Millennium Development Goals (MDGs) and especially those associated with improved maternal health, universal primary education, and reducing acute poverty in the region. It is in recognition of this role that this policy-makers' booklet specifically emphasises the importance of ensuring access to IBSE methods for girls in sub-Saharan Africa.



# GIRL EDUCATION IN SUB-SAHARAN AFRICA

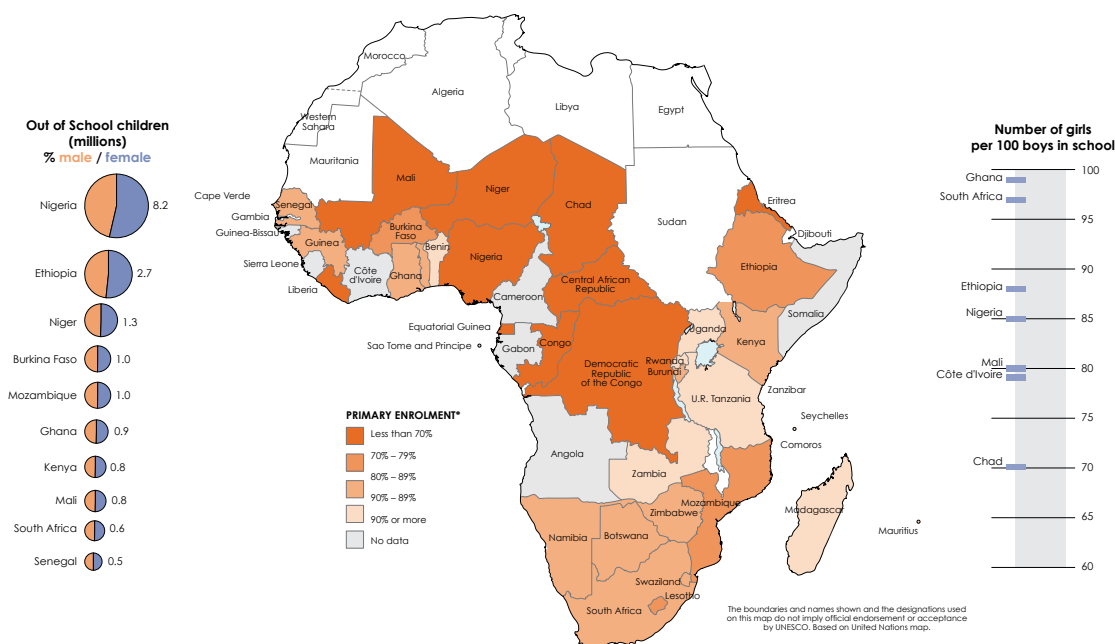
## HISTORICAL CONTEXT

Education is the process by which society deliberately transmits its accumulated knowledge, skills and values from one generation to another. Put differently, education is the vehicle to advance the knowledge, economic and social status of society. In Africa the focus has been for many years on educating boys rather than girls for political, social and economic reasons. Boys were groomed to fulfill societal roles outside the home as primary breadwinners, while girls were

encouraged to focus on roles within the home as homemakers and caregivers. These gender-based socio-cultural practices have led to entrenched gender inequalities in education, the labour market, and the socio-political arenas.

The map below shows the number of girls per 100 boys' enrolled in schools in the sub-Saharan region. Data are for 2007, except for Chad and the Democratic Republic of Congo, which are estimates.

## Sub-Saharan Africa's Educations Challenge



Source: UNESCO (2010), Education for All Global Monitoring Report

It is evident from the above that sub-Saharan Africa (SSA) faces a challenge to increase the number of girls that are educated in general, and in science education, in particular. Convincing parents and communities from different backgrounds to send girls to school is a difficult task which needs constant attention.

Politically, women in many African countries are still under-represented in leadership positions and decision-making at all levels. This situation can also be linked to education and socio-cultural norms and practices. Women in sub-Saharan Africa have a greater burden of labour than men in their roles as homemakers, caretakers, workers, producers and managers of food and environmental resources (water and fuel), yet economically they remain the poorest in sub-Saharan Africa. A variety of initiatives, such as national policies and strategies, quota systems and increased training and skills development of women, have been implemented in the region to reduce these gender disparities.

Regarding education of girls, various instruments have been implemented internationally to encourage increased enrolment and retention of girls in classrooms across the devel-

oping world. In sub-Saharan Africa, a key instrument, the Millennium Development Goals, have acted as a catalyst for increased education of girls.

## MILLENNIUM DEVELOPMENT GOALS ON EDUCATION AND WOMEN

*“Developing countries that have made remarkable social progress, have done so primarily through the empowerment of women, which has had enormous impact in terms of literacy, health and economic well-being of families.”*

**Atal Behari Vajpayee, Indian Prime Minister, 2001**  
<http://dbtindia.nic.in/women/message-secretary.htm>

A significant change of focus occurred regarding Education for All (EFA). At the Millennium Development Goals (MDG) summit in 2000, many countries encouraged development through the improvement of social and economic conditions in the world's poorest countries. Countries committed, among others, to taking urgent steps towards addressing education and inequality:

**MDG 2: Achieve universal primary education**  
**Target:** Ensure that all boys and girls complete a full course of primary schooling.

**MDG 3: Promote gender equality and empower women**  
**Target:** Eliminate gender disparity in primary and secondary education preferably by 2005 and at all levels by 2015.

These goals have provided an opportunity to highlight the importance of education for both boys and girls if sub-Saharan Africa is to meet the challenges of the twenty-first century.

According to the EFA Global Monitoring report (UNESCO 2008: 4), '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% to 70% between 1999 and 2006, an annual increase six times greater than during the decade before Dakar.' However, in 2006 some 75 million children (55% of these being girls) were not in school worldwide and almost half of this number was from sub-Saharan Africa (UNESCO, 2008). Given this figure, it is important to look at various initiatives that have been adopted in the region to promote girl child enrolment in education.

## INITIATIVES TO IMPROVE GIRL EDUCATION IN SUB-SAHARAN AFRICA

A number of initiatives are geared at strengthening gender research to improve girls' and women's education in Africa. These include:

- The Girls' and Women's Education Initiative of World Education, a non-governmental organisation, promotes initiatives to help girls stay in school and leverages funding for girl education in the region.
- The USAID Africa Education Initiative supports education for African girls at primary and secondary school level.
- The World Bank Group, UNICEF and UNESCO, have directed financial and human resources to sub-Saharan African countries with significant gender disparities in education as part of the EFA Initiative.
- The Forum for Africa Women Educationalists leverages funding for bursaries for girl education, implements targeted programmes and projects on issues affecting the girl child, and undertakes research on issues related to gender and education in sub-Saharan Africa.

Through these initiatives, most sub-Saharan Africa governments have prioritised issues related to empowering and educating girls and women, and in alignment with the

African proverb below, have realised that these activities will increase global competitiveness and serve as catalysis for sustainable development in the region.

*"Educate a boy, and you educate an individual.  
 Educate a girl, and you educate a community."*  
**African proverb**

Science education for girls can provide a foundation for girls to engage in science-related careers in the future, which, in turn, means active participation in seeking solutions for developmental problems in the sub-Saharan Africa region.

## SCIENCE EDUCATION FOR GIRLS

Although there has been tremendous progress in girl education in sub-Saharan Africa, the Science, Technology, Engineering, and Mathematics (STEM) fields have continued to see an under-representation of girls. In science education, studies have shown that men are still dominating and it has become important to attract more girls into these fields. Girls have been hindered to pursue science based on a number of misconceptions that people have about science.

Some of these misconceptions are that:

- Boys are smarter than girls
- Science is hard and therefore girls will not cope
- Science is for boys or "tom-boys"
- Science is not rewarding
- Scientists are mad
- Scientists are nerdy
- Girls believe they have a fixed amount of intelligence (which is below what is required to do science)

Additionally, there are various factors that have been identified as hindering girls in pursuing science education, including:

- A lack of self confidence in girls of their ability to master science and math concepts from early education.
- Lack of parental, guardian, teacher and role model support to encourage the pursuing of science subjects.
- Girls tend to have different learning styles than boys, which are not often considered in the curriculum and teacher development process. One of the largest gender differences in cognitive abilities is found in the area of spatial skills, with boys and men consistently outperforming girls and women, especially on measures of mental rotation. If girls are taught in environments where there are opportunities to develop their spatial skills, they are more likely to consider a career future in STEM.
- Many classroom environments (seating arrangements, teaching techniques) are intimidating for girls who tend to shy away.
- Teacher attitudes and instructional materials that reinforce gender stereotypes, for example, teachers tend to favour boys in maths and sciences classes in experiments and classroom discussions, and expect boys to take the lead.
- Many socio-cultural beliefs (family roles, perceptions of the importance of girl education) are a great hindrance



to science education for girls.

- A lack, in some countries, of financial support structures that support science education for girls.

Given these factors, it is important to explore various ways of exposing girls to science education in the region, and ensure that teachers are sensitised to the needs of girls when conducting classroom science and mathematics activities.

## EXPOSING GIRLS TO SCIENCE

Abject poverty and other social-political and cultural factors magnify gender disparities in science education for girls. It has been demonstrated that the socio-economic development of a country is closely linked to the educational level of its population. With a majority of the population in sub-Saharan Africa being women, there is a need to explore ways that encourage access to education and specifically, STEM, as this will further engage girls and women in the socio-economic development of their countries. The following statements should be considered in this regard:

- It has been observed that women have a unique way of working together. This will bring new dynamics to the STEM workforce, and the combination of men and women in this field will bring innovative solutions to difficult problems.
- When girls are taught that their intelligence can expand with experience and learning, they do better and are more likely to continue to study science in the future. When they understand the connection of science and technology to their surroundings, friends and family and, their society, they will be more interested in science. Attracting and retaining more girls in STEM will maximise innovation, creativity and competitiveness.

*“Ideas are best introduced when students see a need or a reason for their use – this helps them see relevant uses of knowledge to make sense of what they are learning.”*

## KEY WAYS OF GETTING GIRLS INTERESTED IN STEM INCLUDE:

- Girls need to be increasingly exposed to successful female role models and mentors in STEM.
- Science-related activities and experiments should be structured such that girls are able to explore, explain, extend, and evaluate their progress.
- Mathematics is critical to the knowledge of science. There is a need to build girls' mathematical skills during early education.
- Bring "girl-friendly" instructional resources to class.
- Develop girls' oral and writing skills.
- Facilitate guided discovery during science lessons.
- Parents should also encourage girls to be confident about their ability to do science.
- Parents and teachers need to teach children that intellectual skills can be acquired and that physical strength is not related to the intellectual capabilities.
- Encourage after school and weekend science clubs.

IBSE is a pedagogical technique of teaching science and a way in which girls can be exposed and encouraged to love science and the focus of this policy-makers' booklet. IBSE resonates with the following paraphrase of a Chinese proverb:

*“Tell me and I forget, show me and I remember, involve me and I understand.”*

The discussion above has provided information on the state of education and science education for girls. It has been noted that there is a critical need for increased enrolment of girls in science education. The next section provides information on IBSE, and argues that this is a pedagogy that can be used to make science appealing to girls and further build a love for science among girls.

## INQUIRY-BASED SCIENCE EDUCATION

### DEFINING IBSE

*“Inquiry-based science education comprises experiences that enable students to develop understanding about the scientific aspects of the world around through the development and use of inquiry skills.”*

*Harlen and Allende, 2009:11*

According to Beerer and Bodzin (2004), IBSE incorporates the following key elements, which are often used by scientists in their scientific research:

	It is based on observation
	It is based on experimentation
	Asking questions
	Making hypotheses
	Designing investigations
	Grappling with data
	Drawing inferences
	Redesigning investigations
	Building and revising theories





"Any pedagogy must 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 as cited by Kgabi, 2010). In IBSE, learners are encouraged to learn through exploring, discovery and investigation. There is a connection between the learning and home environment in such a way that children are able to identify with the learning process.

When IBSE is implemented in a gender sensitive manner, both boys and girls are afforded equal opportunities to ask questions and carry out investigations without discrimination based on gender and physique. This equality in learning ensures that girls are not exposed to the bias that boys are better in mathematics and that careers in science encroach on a man's world. IBSE plays a critical role in both attracting girls into science and instilling a love of science. This can be done successfully by **relating science to activities that girls, in particular, will understand.**

## THE HISTORY OF IBSE

IBSE can be traced back to the 1950s, when Jean Piaget investigated the different ways in which children thought and processed information. In the 1960s and 1970s, scientists 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 schoolchildren. 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 appropriate curricula. Constructivism became a dominant theory of learning. Since around 1990, IBSE has become the most widely advocated teaching approach among science education researchers and leaders.

## THE FEATURES OF IBSE

According to IAP (2006:4), IBSE is in practice when:

- Students are developing concepts that enable them to understand the scientific aspects of the world around them through their own thinking, using critical and logical reasoning about evidence that they have gathered. This may involve them in first-hand manipulation of objects and materials and observation of events; it may also involve them in using evidence gained from a range of information sources, including books, the Internet, teachers and scientists.
- Teachers are leading students to develop the skills of inquiry and an understanding of science concepts through the students' own activity and reasoning. This involves facilitating group work, argumentation, dialogue and debate, as well as providing direct exploration of and experimentation with materials.



## The Differences between IBSE and the Traditional Approach

IBSE	TRADITIONAL
1. Focus on using and learning content as a means to develop information-processing and problem-solving skills	1. Focus on mastering of content and less emphasis on development of skills
2. Learner centred	2. Teacher centred
3. Teacher is a facilitator of learning	3. The teacher focuses on giving information, and the learners must receive it
4. Emphasis on 'how we come to know what we know'	4. Emphasis on 'what we know about science'
5. Learners are more involved in the construction of knowledge through active involvement	5. Learners are recipients of knowledge and less questioning is expected
6. Assessment focuses on the progress of skills development and content understanding	6. Assessment is focused on the one right answer
7. Learners are encouraged to search and make use of resources beyond the classroom and the school	7. Resources are limited to what is available in the school and there is no emphasis on the use of resources in the learner's outside environment
8. Emphasis on learning things through experimentation	8. Emphasis is on memorising scientific concepts

### WHERE HAS IBSE BEEN IMPLEMENTED?

Various forms of IBSE, which incorporate the above features, have been implemented in different parts of the world. Some examples are provided below:

#### 1. FRANCE

**La main à la pâte** (LAMAP) was introduced in 1995 by Georges Charpak as a small-scale experiment in 344 classes in France. In 1998, the *Ten Principles of LAMAP* was published as a guideline for teachers, (<http://www.lamap.fr/>) By 2000, the programme had been extended to over 5 000 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 in France. Each year, numerous resources for LAMAP are published. Currently, approximately 50% of science teachers 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, France. An interdisciplinary team of 15 full-time staff members work on LAMAP. The programme receives funding from the Ministry of Education, other public institutions, and various private and international organisations.

The programme is based on the following ten principles:

#### THE TEACHING APPROACH

1. Children watch an object or phenomenon in the real world and experiment with it.
2. During their investigations, the children argue and reason, discussing their ideas and results, building their knowledge.

3. Activities offered to students by the teacher are organised in sequence to ensure progression of learning. Learner autonomy is encouraged.
4. A minimum of two hours per week is devoted to a science theme for several weeks. Continuity of activities and teaching methods is ensured throughout the school.
5. The learners keep a notebook where their investigations and experiences are recorded in their own words.
6. The major objective of the programme is to ensure progressive learning of science concepts and techniques by learners, accompanied by an improvement in written and oral communication skills.

#### THE PARTNERSHIPS

7. Families and communities are requested to actively participate in the learning process in classes.
8. Local partners at universities, colleges and other science organisations volunteer to assist the learners with their investigations and the learning process.
9. Local scientists and trainees assist in the development of teachers.
10. The website provides the teacher with module material, ideas for activities, and any technical assistance they may require. Through the websites, teachers are also able to engage in collaborative work and dialogue with other colleagues, trainers and scientists.

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: through discussion and debates at the various stages of the inquiry process, and writing in the science notebook;
- development of interaction between pupils: disagree-



ments are settled by doing the experiments as a group, and social and life skills are learnt;

- to change the perception of science by society.

Conclusions drawn from the implementation of the programme are:

- 'In 2004, it was shown that more than 35% of children really practice science in their classroom, whereas there were only 3% when the operation was started, thus demonstrating the efficiency of the effort undertaken' (Folco and Lena, 2005: 16).
- 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.

## 2. AUSTRALIA

The Australian Academy of Science has partnered with the Australian Department of Education, and Employment and Workplace Relations (DEEWR) to develop and implement 'PrimaryConnections: Linking science with literacy'. PrimaryConnections is an innovative approach to teaching and learning which aims to enhance primary school teachers' confidence and competence for teaching science. Prima-

ryConnections focuses on developing students' knowledge, skills, understanding and capacities in both science and literacy.

PrimaryConnections is a multi-pronged approach which uses a professional learning programme complimented by curriculum resources based on ongoing research. The five underpinning principles of the Primary Connections inquiry approach are:

- 5Es Teaching and Learning Model
- Embedded assessment
- Linking science with literacy (and numeracy)
- Student-planned investigations
- Cooperative learning

### THE 5ES TEACHING AND LEARNING MODEL

The 5Es Teaching and Learning Model is used for engaging the learner on 'why we need to know something', as well as supporting teachers and building their confidence.



## PrimaryConnections 5Es Teaching and Learning Model

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

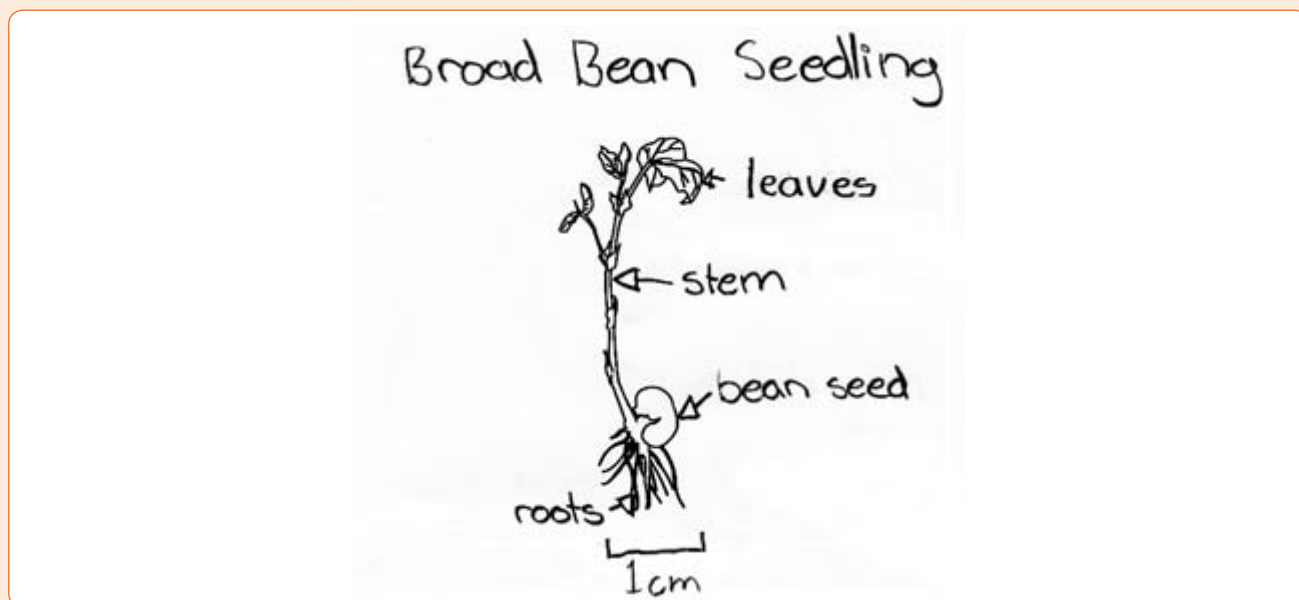
### EMBEDDED ASSESSMENT

Through embedded assessment, PrimaryConnections seeks to establish what should be assessed and why it should be assessed. PrimaryConnections tries to encompass scientific literacy in its implementation. The types of assessment that the project embraces are:

- diagnostic: assessment for learning, which reveals students' prior knowledge and is used for planning following lessons;
- formative: assessment of learning, which enhances learning through giving feedback;
- summative: assessment as learning through the work samples generated by learners.

### LINKING SCIENCE WITH LITERACY (AND NUMERACY)

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.

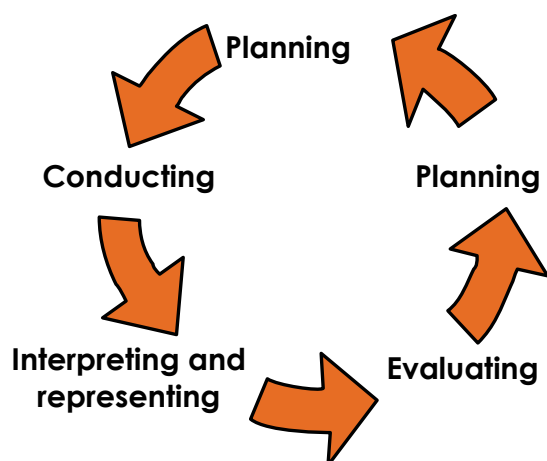


The connection between inquiry and literacy is depicted in this diagramme.  
(Source: Australian Academy of Science Primary Connections Programme)

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.

### STUDENT-PLANNED INVESTIGATIONS

Students are encouraged to follow the following pattern in their investigations.



PrimaryConnections encourages the teaching of science through argument. This is to overcome students' tendencies to discount the data that they have collected if the data contradict their current thinking regarding their prediction or outcome of their investigation and to provide explanations which include claims with little evidence or justification drawn from the data that they have collected or observed. By asking students what their evidence for their claims or ideas is, they learn to reason and justify their thinking.

### COOPERATIVE LEARNING

PrimaryConnections uses a teaching strategy where learners are encouraged to work in small teams comprising learners with different roles – manager, director and speaker. This method of teaching increases learner retention, encourages learning from one another, develops learners' oral, communication and reading skills and has been known to promote social skills and positive interdependence (Peers, 2010).

## 3. PRIMARY SCIENCE PROGRAMME

The Primary Science Programme (PSP) started in 1984 and is aimed at teachers in primary schools (Grade R to Grade 7) in the Western Cape and in other provinces by invitation. The Programme 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 and paper, with literacy integrated into all the lessons. PSP aims to build confident teachers who enjoy and understand what they are teaching so that the lessons will be effective for the learners.

The Programme 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 observing 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.

## WHY IBSE IN SUB-SAHARAN AFRICA

The implementation of IBSE in sub-Saharan Africa would provide the following benefits:

- Inquiry-based science education:**
- Encourages scientific thinking through the testing of ideas
  - Learners are encouraged to tap into their everyday experiences to reason out a particular experiment and its outcome
  - Encourages learners to gain a greater understanding of concepts (Harlen and Allende, 2009)
  - Encourages students to actively understand the nature of science through active learning
  - Encourages a greater understanding of why people know what they know about science
  - Enables the development of scientifically literate citizens (Beerer and Bodzin, 2004)
  - Plays a critical role in enhancing the numeracy and literacy levels of learners

IBSE should be implemented at the primary school level since it has been shown that science at this level plays a 'significant role in the development of scientific understanding, enquiry skills and attitudes' amongst learners. (Harlen and Allende, 2009:13).

According to Harlen and Allende (2009), IBSE at primary school level:

- encourages the cementing of scientific concepts and knowledge by young learners;
- enhances the development of children's inquiry skills;
- assists in setting a foundation for the development of attitudes and perceptions about science at an early age.



The successful practice of IBSE at primary school level is evident when students experience the following:

- a. Gathering evidence by observing real events or using other sources
- b. Pursuing questions which they have identified as their own even if introduced by the teacher
- c. Raising further questions which can lead to investigations
- d. Making predictions based on what they think or find out
- e. Talking to each other or to the teacher about what they are observing or investigating
- f. Expressing themselves using appropriate scientific terms and representations with understanding both in writing and talk
- g. Suggesting ways of testing their own or others' ideas to see if there is evidence to support these ideas
- h. Taking part in planning investigations with appropriate controls to answer specific questions
- i. Using measuring instruments and other equipment appropriately and with confidence
- j. Attempting to solve problems for themselves
- k. Using a variety of sources of information for facts that they need for their investigation
- l. Assessing the validity and usefulness of different ideas in relation to evidence
- m. Considering ideas other than their own
- n. Reflecting self-critically about the processes and outcomes of their inquiry

*(Source: Harlen and Allende, 2009: 14 as adapted from IAP 2006)*



**IBSE is also successful when teachers practice the following:**

- a. Providing opportunity for students to encounter materials and phenomena to explore or investigate first hand
- b. Arranging for discussion in small groups and in the whole class about procedures that are planned or have been used, to identify alternatives and ways in which the approach to particular investigations might be improved
- c. Encouraging tolerance, mutual respect and objectivity in class discussion
- d. Providing access to alternative procedures and ideas through discussion, reference to books, resources such as the Internet and other sources of help
- e. Setting challenging tasks whilst providing support (scaffolding) so that students can experience operating at a more advanced level
- f. Teaching the techniques needed for advancing skills, including the safe use of equipment, measuring instruments and conventional symbols
- g. Encouraging students through comment and questioning to check that their ideas are consistent with the evidence available
- h. Helping students to record their observations and other information in ways that support systematic working and review
- i. Encouraging critical reflection on how they have learned and how this can be applied in future learning
- j. Using questioning to encourage the use of inquiry skills

*(Source: Harlen and Allende, 2009: 15 as adapted from IAP 2006)*

## CHALLENGES IN ADOPTING AND IMPLEMENTING IBSE IN SUB-SAHARAN AFRICA

### CHALLENGES FOR TEACHERS

- Inadequate teacher training on IBSE methods
- Lack of in-depth science content and concept knowledge of teachers
- Lack of access to quality resources and facilities for teaching, for instance, access to the Internet and teacher support material
- Not enough time is dedicated for the in-service training of teachers
- Teachers are overloaded with a range of responsibilities

### CHALLENGES ON THE IMPLEMENTATION OF IBSE

- The current student-teacher ratios do not allow individual attention
- The multilingual nature of most classrooms can pose a problem when implementing the approach
- Current focus of the curriculum is on examination training rather than knowledge generation
- School timetables are not flexible enough to accommodate the needs of IBSE
- Natural sciences are not given sufficient teaching time in school timetables
- Attitudes towards change among teachers, learners and policy-makers are insufficient for successful implementation
- Local research on implementing IBSE approaches in the sub-Saharan Africa classroom is lacking

### CHALLENGES FOR THE EDUCATION SYSTEM

- Inadequate funding for human resources, curriculum changes, training, and materials for the implementation of IBSE
- Lack of support and political will from government and education ministries on implementation of IBSE approaches
- Disconnect between education practitioners, educators and policy-makers in the process of developing education curricula and resources
- Inadequate understanding by policy-makers on how to achieve educational reform
- A lack of understanding of the link between science and numeracy and literacy campaigns
- Lack of efficient and effective management of schools

### CHALLENGES FOR THE GIRL CHILD

- Girls lack science role models and mentors within their families and in the society at large
- The effects of poverty on the ability of girls to access education
- Social and cultural factors, which restrict girls' entry into science subjects and, in some cases, the education system in general
- Traditional and cultural expectations that lead to girls being socialised into gender-specific roles that inhibit participation in science education
- Lack of career guidance that informs girls of science-related careers
- Infrastructure and facilities at schools that are not female friendly
- In some countries, policies of exclusion have been adopted
- Examples and pictures used in science textbooks are not appealing or interesting to girls

## RECOMMENDATIONS ON THE WAY FORWARD IN IMPLEMENTING IBSE IN SUB-SAHARAN AFRICA

### GENERAL RECOMMENDATIONS

- a. Integrate IBSE approaches in science classrooms in sub-Saharan Africa.
- b. Provide adequate and accurate information on the value and importance of IBSE for education in sub-Saharan Africa.
- c. Analyse and customise *La main à la pâte*, *PrimaryConnections* and other IBSE programmes for sub-Saharan Africa region, taking into account culture, context and diversity.



- d. Analyse the following issues through a gender lens in the region to ensure effective implementation of IBSE:
  - Teacher-student interactions
  - Classroom management strategies
  - Classroom engagement
  - Gender interactions in small groups
  - Perceptions about science
  - Strategies to improve practice.
- e. Pilot teacher-training workshops on IBSE, including follow-up support, resources and training of trainers.
- f. Introduce science modules in school curricula at earlier levels of primary school.
- g. Share experiences with other countries on implementing IBSE in different contexts.

## SPECIFIC RECOMMENDATIONS TO POLICY-MAKERS

### ON IMPLEMENTING IBSE

- a. **Endorse** the integration of IBSE into the school curricula
- b. **Support** pilot projects to introduce IBSE into schools
- c. **Lobby** to strengthen current science curricula through the IBSE approach
- d. **Address** the communication gap between practitioners, educators and policy-makers involved developing curricula
- e. **Focus** on implementing pilot workshops and projects for teacher training and teacher trainers on IBSE

### ON TEACHER TRAINING AND DEVELOPMENT

- a. **Lobby** for implementation of IBSE in training institutions
- b. **Approve** financial and other resources for developing teachers on IBSE
- c. **Fund** IBSE teaching resources, facilities, toolkits, and other support materials
- d. **Support** and **encourage** continuous in-service training of teachers on science and mathematics concepts, content and skills in facilitating and moderating discussions among students
- e. **Lobby** for developing adequate evaluation and assessment processes for IBSE to fit with national assessment requirements and guidelines. This will further **support teachers** in implementing IBSE

### ON IBSE FOR GIRLS

- a. **Lobby** for gender mainstreaming in science and mathematics teaching
- b. **Sensitise** teachers on teaching methodologies and activities to ensure **equal participation** of girls and boys
- c. **Advocate** increased career guidance for girls on science careers
- d. **Encourage** implementation of role model and mentoring programmes aimed at girls
- e. **Endorse** and **support** practical campaigns exposing girls to science in the workplace
- f. **Lobby** for change in socio-cultural and family attitudes negatively influencing science education for girls
- g. **Support** opportunities to expose girls to activities encouraging IBSE

## RECOMMENDATIONS FOR ACADEMIES OF SCIENCE IN SUB-SAHARAN AFRICA

- a. **Provide** evidence-based policy advice to governments on IBSE – its features, successful contextual implementation, advantages and disadvantages
- b. **Lobby** governments to adopt IBSE
- c. **Identify** monitoring and evaluation mechanisms for implementing IBSE
- d. **Assist** government in consolidating information on IBSE
- e. **Forge** partnerships with academies where IBSE has been introduced and expand their knowledge on implementation processes
- f. **Offer** volunteer assistance in classrooms
- g. **Coach** and **mentor** teachers on IBSE
- h. **Act** as role models to girls and provide career guidance to encourage girls to take up science subjects





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