*Proceedings*

*Asian Regional IAP Seminar*

# The Generation of "Experimental Materials and Learning Modules for Science Education

**October 24 – 25, 2002**

**New Delhi, India**

***Organised by***


The Indian National Science Academy

Indian Academy of Sciences

National Academy of Sciences of India

The Mexican Academy of Sciences

The French Academy of Sciences

Inter Academy Panel

Inter Academy Council

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## FOREWORD

Indian National Science Academy lays special importance towards science capacity building in the country.  Towards this, the Academy has taken several measures over the years.  At the international level, the Academy is collaborating and coordinating with other agencies to address issues pertaining to science education which are common to many countries.  The Academy is a constituent member of the Inter Academy Panel (IAP).  As a part of the IAP initiative, the Academy has been requested to lead a programme on Science Education particularly for the Asian region.  An Asian Regional IAP Seminar on the Generation of Experimental Materials and Learning Modules for Science Education was organized during October 24-25, 2002 in New Delhi, India.  The Academy is happy to bring out the proceedings of the Asian Regional IAP seminar in the present form.  It is our fond hope that such measures would ensure mutual sharing of experiences among scientists in different countries in the area of science capacity building to fulfill the objective of IAP 'Taking Message of Science to primary school children and adult illiterates as a global initiative'.

M.S. Valiathan
President, INSA

# PREFACE

Asian Regional IAP seminar on the General of Experimental Materials and Learning Modules for Science Education was held in New Delhi, India during October 24-25, 2002 immediately following the TWAS General Assembly(Oct. 19-23, 2002). The Seminar has been jointly organized by the Indian National Science Academy, Indian Academy of Sciences, National Academy of Sciences of India, The Mexican Academy of Sciences, The French Academy of Sciences, Inter Academy Panel and Inter Academy Council.

Several Asian countries participated in the meeting. There was an active participation from members of TWAS and presentations from Brazil, France, African region. The programme of the two-day seminar is appended at the end of this volume. There were 16 presentations from different Academies of which 11 were from the countries of the South. The National Science Research Centre, Washington DC, USA, Pontifical Academy of Sciences and the French Academy of Sciences participated in the seminar with presentations. Many of the presentations were followed by lively discussion and ended with a concluding session. The presentations which the reader of this volume will see are transcribed versions from the overhead presentations. In a few cases, I have been lucky to have a written-format as well. It is likely that there might have been certain omissions in the printed version. I assure that these are inadvertent and I seek the authors' indulgence.

A summary of the concluding session is included as a last chapter. I have taken the privilege by including the brief report on the seminar Science Education Programme, Trends and Future Initiatives organized by INSA during May 2002 in New Delhi. I am very thankful the staff at the INSA for their untiring services and particularly to Shri S.K. Sahni, Executive Secretary, INSA for providing all the help. It is a pleasure to thank all the secretarial staff at the Jawaharlal Nehru Centre for Advanced Scientific Research, Jakkur, Bangalore, for their ever-ready assistance to bring out this volume.


V. KRISHNAN
Convener, Science Education
Programme, INSA
Jawaharlal Nehru Centre for
Advanced Scientific Research
Bangalore, INDIA

## Opening Session

The seminar was opened with a welcome from the Convener, Professor V. Krishnan. He outlined the genesis of the seminar and also brought to the attention the initiative taken by INSA in the organization of a preconference held in New Delhi in May 2002 on Capacity Building in Science and Technology – Science Education Programme – Trends and Future Initiatives. This meeting was largely attended by the various institutions and NGOs in India working in the field of Science Education. The meeting brought forth many suggestions and these are presented in the Convener's Remarks at the end. Professor G. Mehta addressed the seminar elaborating on the initiatives of IAP in the organization of different regional workshops. He outlined the importance of such meetings towards experience sharing leading to development, a viable model science education programme.

The keynote address was delivered by Prof. C.N.R. Rao, President, TWAS. The lecture covered essential points in the science education in developing countries, the importance of science capacity building in the countries and the widening gap between the countries of the North and South. This lecture emphasized the principle of Science for All Citizens and the different methodologies. The two-volume CD on Learning Science authored by Prof. C.N.R. Rao was shown to the audience and it was highly appreciated. The multimedia package was brought out by the Educational Technology Unit of Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India and INSA had provided the initial support for this venture under its Science Education Programme activity. A few CDS were distributed to the participants. The CDs have many interesting features and user friendly. The contents of the CD are shown here.

LEARNING SCIENCE

| | | |
|---|---|---|
| AUTHOR | : | CNR Rao |
| GRAPHICS | : | Indumati Rao |
| COLLATION | : | Jatinder Kaur |
| PRESENTATION | : | Sanjay Rao |
| DEVELOPMENT | : | D.K. Bhaskar |
| ARCHITECTS | | Jatindar Kaur |

LEARNING SCIENCE VOL I

UNDERSTANDING UNIVERSE
AIR AROUND US
OUR OWN EARTH
EXPLORING THE SOLAR SYSTEM
ALL BOUT WATER
ANIMAL AND PLANT KINGDOM

LEARNING SCIENCE VOL II

LEARNING PHYSICAL PRINCIPLES
THE WORLD OF CHEMISTRY
ENERGY IN DIFFERENT FORMS
BIOLOGY AND LIFE

Learning Science is about science in action around us. This interactive self-study and resource CD-ROM is useful for middle-level school children.

# ENQUIRY-BASED SCIENCE EDUCATION IN BRAZIL: BACKGROUND AND RECENT EVENTS

***E.M. Kreiger***
(Brazilian Academy of Sciences, Brazil)

The recent events and measures taken by the Brazilian Academy of Sciences and the Government in the area of science education are summarized here. It also lists the background of education and difficulties encountered interms of international isolation and monolingual bibliography. Two factors essentially sum up the background.

- Neglect of a basic organization for the primary school
- Two education networks; one, preparing for higher education; the other, taking children out of the streets and vice, and preparing for work. Currently: private and public networks.

(from Carlos Jamil Cury, head of the Basic Education Committee of the CNE in "Seminário International Sobre Políticas Públicas no Ensino Médio", 1998)

The indicators for basic education in Brazil is given in the box:

- In 1989, only 20% of the children enrolled in elementary schools completed the fourth grade.
- But, in 2001: 100% (universal coverage)
- The average number of years of formal school attendance of Brazilian workers was 4.7
- New policies for basic education since 1945.
- A false dilemma: basic education vs. higher education.

The various programmes for science education are listed below:

- PADCT, 1983-present (three phases)
- Science Education subprogram (SPEC) in the first two phases (1983-1992)
- Overall expenditure*: ca*.US$25M.
- Project types: resources and materials, museums, teacher training
- Main results: new resources, publications, researcher-teacher networks
- Also, some problems leading to SPEC exclusion from PADCT.
- *S: Prociências (Ministry of Education), Fapesp*

One of the main factors contributing to the difficulty of accusing science education being international isolation. The following statement bears the testimony

- "Felizmente, fomos poupados do perigo de cometer muitos erros quando o laboratório recebeu uma verba do BID – Banco Inter-Americano de Desenvolvimento, o que nos permitiu mandar dez pesquisadores nossos para observar laboratórios similares em outros países (USA, Canadá, Inglaterra, Noruega, França, Espanha e Israel) e trazer dez persquisadores estrangeiros para curtos períodos de trabalho conosco".

*http://www.futuro.usp.br/ef/menuingles/m_baixod_portugues.htm*

An evidence of international isolation: A monolingual bibliography (from 1998 FAPSSP project) is listed below:


- AMARAL, I.A. Ambiente, Educação ambiental e Ensino de Ciências. In Lima, M.M.S. et,al Ciências nas Escolas de 1o.Grau. Texto de Apoio à Proposta Curricular de São Paulo. SEE.CENP, 1992, pág. 39-62
- COMPIANI, M. As Geociências no Ensino Fundamental: um estudo sobre o caso sobre o tema. "A Formação do universo" – Tese de doutorade, FE/UNICAMP – Cap. 2 Campinas, 1996.
- CANINO, N. Ideas previas y cambio Conceptual en Astronomia. Un estudio com Maestros de primaria. Ensenanza de Las Ciencias, 1995, vol. 13 (1) pág.81-96.

- DAVIS, C; ESPÓSITO, Y.L. O papel e Função do Erro na Avaliação escolar. Cad. Pesq. (74) agosto 1990.-pág.71.
- FALCÃO, H.A. Perfil Analítico de Águas Minerais. Boletim n.49, vol.2, Rio de Janeiro, DNPM, pág109, 1978.
- UNCIARTE, M.R.; CONZALEZ, S.V. E VIRELLA, F.A. Ciencias Naturales 3 Ediciones s/m-Joaquin Tumia 39 BUP.
- LINDOYANO FONTES PADIOATIVAS LTDA. Encartes e Documentos.
- MENDONĢA, J.L.G. DE, GUALDI, O.J. Água, o mapa da mina.
- MOREIRA,M.A. O Professor pesquisador como instrumento de melhoria do Ensino de Ciências. Em Aberto, ano VII, n. 40, pág,43-54, Brasília Out/Dez 1988.
- SILVA, R.B.G. Da As agues subterrâneas: Umvali recurso que requer proteo. CEPIS, Lima Peru, 260, 1986.
- SCHÖN, D.A.-Formar professors como profissionais reflexivos, in NÓVOA, A. Os professors e sua formções Dom Quisote, Inst. Inovação Educacional, Lisboa, pág. 79-91, 1992.

The current situation of science education in Brazil has the following components:

- A large number of groups working on science education.
- Low number and strength of international connections, but important exceptions.
- Small impact on major education (states, municipalities) systems.
- Focus on high schools, neglect of K-12 (Kindergarten to 12 years old)
- Some successful, small-scale experiments on inquiry-based science teaching in early grades.

The commitments of the Brazilian Academy of Sciences are summarized below:

- Support to two groups connected to “La Main à la Pâte” project:
  - at Estação Ciência, directed by Ernst Harburger, the University of São Paulo
  - at Fiocruz, directed by Danielle Grynzspan in Rio de Janeiro

- A project: homepage for Internet support to school teachers.
- Creation of a researcher-teacher network.

The working fronts are:

- Providing political support and prestige to groups involved in capacity-building for science education in all ages.
- Discussion with government officials to help reaching ways to satisfy the funding needs as well as establishment of new programs.
- Implementing new partnerships with academic personnel interested in the improvement of science teaching.

The conclusion and suggestions are listed below:

- Plenty of activity, little assessment and implementation.
- Need to introduce results in education policy-making.
- Need to consolidate efforts around well-chosen themes.

# INNOVATIONS IN SCIENCE TEACHING
# INNOVATIONS IN EXPERIMENTS AND INNOVATIONS IN CITING EXAMPLES

***Shamsher Ali Mohammed***
(Department of Physics, Dhaka University, Bangladesh)

Purpose: Creating interest in science and generating a spirit of enquiry.

- Science is not merely talking science is "doing things"
- Doing science for what? Doing things to verify how nature works
- Who should " do" things?

  Teachers? No

  Students? Yes

The students should be the key players

The teachers should be passive watchers

Equipment needed:

(a) Use of local materials may be encouraged ( materials in the students own environment)

(b) Experiments must be based on fun and delight.

Examples : Creation of sound
: Propagation of sound
: Water finds its own level
: Flight of an aeroplane
: Flight of a bird

The last two examples can easily be performed by holding a sheet of paper before a table fan.

Physical Laws governing the cooling.

Efforts of UNESCO in devicing simple experiments 700 experiments are listed.

- Applications of scientific principles

- Innovations in citing examples
- A multidisciplinary approach is needed
- The level of teaching should be kept in view (primary, secondary, tertiary)

Examples:

| | |
|---|---|
| Interdisciplinary | Water (The phase transition of water) |
| Approach of | Exchange of heat between an object and its environment |
| Teaching science | Energy transformations |

**The different branches of science should be connected through examples**

Man’s defence system ⇔ Defence system in nature

| | | |
|---|---|---|
| Shelling | ⟷ | Tortoise |
| Radar | ⟷ | Bat |
| Camouflage | ⟷ | Lizard |
| Teargas | ⟷ | Otter |
| Spikes | ⟷ | Porcupines |
| Poisoned knife | ⟷ | Snake |

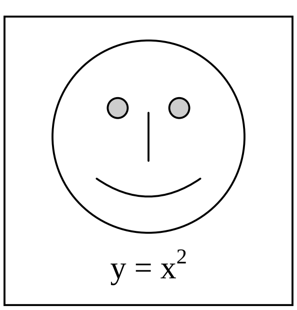
**If science is the name of the game, then what are the laws of the game?**

Law is mathematics. Mathematics is the basic language of nature. Innovations in mathematics teaching:

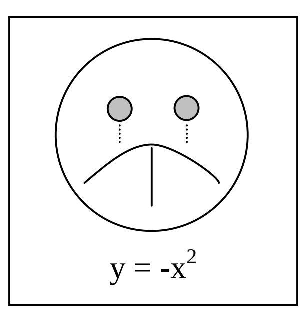
Angular Momentum

MATRIX
CONIC SECTIONS

Hard work success




Little work failure



# Energy Conversion Matrix

| To From ► ▼ | Electro Magnetic | Chemical | Nuclear | Thermal | Kinetic (mechanical) | Electrical | Gravitational |
|---|---|---|---|---|---|---|---|
| Electro Magnetic | | Chemiluminescence<br>(Fireflies) | Gamma reactions<br>($CO^{60}$ source)<br>A-bomb | Thermal radiation.<br>(Hot Iron) | Accelerating Charge<br>Cyclotron<br>Phosphor | Electro Magnetic radiation<br>(TV transmitter)<br>Electrominescence | Unknown |
| Chemical | Photosynthesis<br>(Plants)<br>Photochemistry<br>(Photographic films) | | Radiation Catalysis<br>(Hydrazine plant)<br>Ionization<br>(Cloud chamber) | Boiling<br>(Water steam)<br>Dissociation | Dissociation by hydrolysis | Electrolysis<br>(production of aluminium)<br>Battery discharge | Unknown |
| Nuclear | Gamma neutron reactions<br>($Be^4+y^- \rightarrow Be^8-n$) | Unknown | | Unknown | Unknown | Unknown | Unknown |
| Thermal | Solar absorber<br>(hot sidewalk) | Combustion<br>(fire) | Fission<br>(fuel element)<br>Fusion | | Friction<br>(break shoes) | Resistance heating<br>(electric stove) | Unknown |
| Kinetic (mechanical) | Radiometer<br>(solar cell) | Muscle | Radioactivity<br>(alpha particles)<br>A-bomb | Thermal expansions<br>(Turbines)<br>Internal combustions<br>(Engines) | | Motors<br>Electros action<br>(Sonar transmitter) | Falling objects |
| Electrical | Photo electricity<br>(light meter)<br>Radio antenna<br>Solar cell | Fuel cell<br>Batteries | Nuclear batteries | Thermoelectricity<br>Thermonics<br>Thermo magnetism<br>Ferro electricity | Magneto-hydrodynamics<br>Conventional generator | | Unknown |
| Gravitational | Unknown | Unknown | Unknown | Unknown | Rising objects<br>(Rockets) | Unknown | |

An example is given below to demonstrate the bus fare in matrix form for a journey from a place Gulistan to Gulshan.

Matrix:
Bus fare:

$$
\begin{array}{l l}
\text{To :} & \begin{array}{ccccc} \text{Gulistan} & \text{Press club} & \text{shahbag} & \text{farmgate} & \text{gulshan} \end{array} \\
\text{From} & \\
\begin{array}{l} \text{Gulistan} \\ \text{Press club} \\ \text{Shahbag} \\ \text{Farmgate} \\ \text{Gulshan} \end{array} & \begin{pmatrix} 0 & x & x & x & x \\ x & 0 & x & x & x \\ x & x & 0 & x & x \\ x & x & x & 0 & x \\ x & x & x & x & 0 \end{pmatrix}
\end{array}
$$

The lecture has demonstrated more examples of solving algebraic problems and physical understanding of them. The energy conversion matrix is shown below illustrating how one form of energy can be converted another.

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# THE NATIONAL SCIENCE RESOURCES CENTER:
## A Blueprint for Science Education Reform


***Sally Goetz Shuler***
(Executive Director, National Science Resources Center,
Washington, D.C. U.S.A)


Publication of the seminal report *A Nation at Risk* by the Secretary of Education's National Commission on Excellence in Education in 1983 opened eyes nationwide to shortcomings in American Science and mathematics education. Concerns were based primarily on two critical needs:

- The need for all young people to be scientifically and mathematically literate if they were to participate effectively as citizens in the $21^{st}$ century and in a national workforce increasingly dependent upon workers with science and technology backgrounds.
- The need to remain internationally competitive and maintain the nation's scientific and technical enterprise through the development of U.S. trained scientists and engineers.

In 1985, two years after publication of *A Nation at Risk*, the Smithsonian Institution and the National Academies jointly established an organization dedicated to improving the learning and teaching of science in the nation's 16,000 school districts. The challenge of this new organization – the National Science Resources Center (NSRC) – was to leverage the scientific credibility and prestige of both institutions to catalyze change with teachers and students. The parent organizations charged the NSRC with developing products and services based on research and best practices, involving both the education and scientific communities in its activities, and significantly increasing the number of school districts implementing effective K-12 science programs for all students.

The NSRC spent its first two years, 1986 and 1987, researching two questions:

- What critical factors did school districts need to establish and maintain effective science programs?
- What critical factors would leverage systemic change?

From this basis, the NSRC developed a unique philosophy of science education, a reform model, and a practical theory of action upon which it has based its subsequent work.

### The NSRC's Philosophy of Science Education Reform

The NSRC's philosophy of science education reform is based on research in cognitive development, theories of organizational change, and the impact of program activities on student achievement, and enriched by an in-depth understanding of the unique culture of school systems. The NSRC philosophy centers on the student, the science curriculum, and the infrastructure necessary to bring about successful reform.

### The Student

The NSRC's core values include the following beliefs about students:

- All students can learn science.
- Students learn science best in an inquiry-oriented environment that challenges them to build on their previous knowledge and skills.
- Student learning experiences must be developmentally appropriate.

### Science Education Reform Model

The NSRC's model for science education reform focuses on five critical elements common to effective science education programs: curriculum, professional development, assessment, materials support and administrative and community support.

**Curriculum**:

A comprehensive, inquiry-centered curriculum lies at the heart of effective science education. Curriculum design must provide age-appropriate opportunities for children to expand their conceptual understanding of important science ideas, develop problem-solving and critical-thinking skills, and develop positive habits of mind toward science. The science curriculum should combine hands-on, inquiry-centered investigations of scientific phenomena with opportunities for reading and reflection, discussion and analysis, and writing and independent study. Science curricula must offer students opportunities to apply newly learned concepts and skills to their everyday lives and to integrate science with other areas of study. An effective curriculum incorporates the critical implementation needs of both teachers and districts, aligns with the National Science Education Standards, and is developed using a rigorous research and development process. This process needs to include field testing with geographically and ethnically diverse student populations representing urban, rural and suburban districts throughout the country; assessment of the materials by an external evaluator; and technical review by master teachers and scientists and engineers to ensure their scientific and educational integrity.

The NSRC has made major contributions in the area of curriculum development with release of two series: Science and Technology for children (STC) and Science and Technology concepts for Middle Schools™ (STC/MS™).

**Professional Development**:

Professional development programs need to help teachers assess their knowledge and skills and to differentiate among novice, competent, and expert teachers. For teachers with little to no science background and no experience in using inquiry-centered methodologies, programs initially need to focus on helping teachers become familiar with fundamental science concepts, using inquiry-centered science materials in their classrooms, and developing effective classroom management techniques. Programs for novice teachers should focus on helping them acquire in-depth knowledge of science content, continuously refining the inquiry-centered approach to learning, developing appropriate methods for student assessment, and integrating science with other subject areas within the overall school curriculum. The strategies used to accomplish these goals need to be based on research, use best practices, and center on building a learning community.

**Student and Programme Assessment*:***

Assessment strategies used by teachers, districts, and states need to be aligned with instruction, seen as integral and important to the learning process and use a variety of methodologies. The science curriculum program needs to incorporate pre-embedded, and post-assessment strategies that continuously evaluate student's conceptual understanding and skills, including their prior knowledge and skills and progress made.

The assessment strategies need to be designed so that students can assess their own progress in learning and applying important science concepts and skills and to help teachers examine and modify instruction.

Program evaluations conducted externally are needed to determine whether the science program is accomplishing its goal.  Evaluations should incorporate both a formative component (focusing on the quality and effectiveness of science program activities) and a summative component (focusing on the impact of the program on students' and teachers' attitudes, knowledge, and skills)

**Materials Support**:

Students who engage in inquiry-centered science need a variety of science materials-from hand lenses to magnets to plastic eyedroppers.  An effective system for providing supplies and equipment for teachers of science needs to have efficient methods for ordering new supplies, refurbishing science kits, and ensuring that the materials are delivered to teachers systematically as needed throughout the year.  Centralizing the materials support function makes materials support activities more cost-effective and increases quality assurance.  Centralization most commonly occurs at the school district level; small school districts can consolidate their materials support service by forming a consortium.

**Administrative and Community Support**:

Planning and implementing an inquiry-centered science program requires the support of a broad range of stakeholders, including students; teachers; parents; school district administrators; and community officials representing school boards, corporations, museums, academic institutions, parent organizations, and other groups working to improve science learning and teaching.  These individuals and groups must share a vision of effective science learning and teaching and understand what is needed to create an effective infrastructure to establish a sustainable inquiry-centered science program for all students in their school districts.  These leaders need to be committed to spearheading a K-12 science education reform effort, including educating themselves about inquiry-centered science learning and teaching.  The infrastructure needs to have local and state policies that support an effective science program, including a policy defining science as a core subject of the K-12 curriculum.

To engage a broad range of district and community leaders, support programs need to provide a variety of ways that individuals and organizations can become involved and add value or quality to the district's science program. For example, scientists and engineers, as well as parents, can help leverage support for science education reform. Scientists also can work as colleagues with teachers in the design and implementation of professional development programs. Parents may volunteer time to help replenish science kits in the school district's science materials center. A corporate leader may serve as a spokesperson for science education reform with the business community. Working together, these individuals should form partnerships that will improve the quality of, and ensure a sustained commitment to, the science education program.

**The NSRC's Theory of Action And Accomplishments**:

In 1989, the NSRC developed a theory which holds that the implementation of principles for improving the learning and teaching of science for all students will lead school districts to establish quality infrastructures in support of science education. This, in turn, will lead to increased achievement for all students. The NSRC's principles include the definition of the elements or parts of the system that a school district needs to build and integrate in order to establish an infrastructure for supporting effective science learning and teaching.

To test the theory, the NSRC has been researching, developing, and testing its systemic reform model during the past 13 years. The NSRC disseminates the model through six-day immersion courses focused on elementary and middle school science. During the first eight years of the outreach effort, the NSRC targeted mainly the 1,000 largest of the nations' approximately 16,000 school districts – those having at least 10 or more elementary schools and a total of approximately 5,000 to 7,000 students-to invite to these course.

Five to seven-member strategic leadership teams made up of a cross-section of the decisionmakers in a school district – including teacher leaders; the science coordinator; the curriculum; the curriculum director; a senior administrator, preferably the assistant superintendent or superintendent; and a high-level scientist or engineer from a corporation, academic institution, federal research laboratory, or museum-participate in the courses. These leaders should be committed to spearheading a science education reform effort, beginning with educating themselves about inquiry-centered science learning and teaching.

Teams apply for participation by submitting a needs assessment, committing time and finances, and fostering the active involvement of a science-rich institution whose leaders will work with the district to implement the strategic plan and build a broad base of support.

Since 1989, the courses-first called “Science Education Leadership Institutes” and later “Science Education Strategic Planning Institutes” – have focused on accomplishing three important goals:

- Assisting leaders in clarifying and developing a shared vision of effective science learning and teaching through direct, hands-on experiences modeling these principles.
- Providing the teams with access to research and best practices for the establishment of the infrastructure needed to support this vision. To acquire this knowledge, teams participated in five days of intensive interactive learning, with each day focused on one of the five elements of the NSRC science education reform model.
- Providing the time, resources, and expertise to help each team apply the knowledge gained during the Institute to the development of a five-year strategic plan for reform,

The Institutes bring together 15 to 20 school district teams and a faculty of 16 to 20 leaders. The learning experiences have provided both the research and examples of models that can be contextualized and applied to the development and implementation of a five-year strategic plan for reform. Teams learn about models of challenging curriculum, professional development programs for teachers, materials support systems, assessment strategies that aligned with inquiry-centered learning and teaching, and strategies for building administrative and community support. They use this information daily to contribute to the development of as five-year strategic plan. The culminating event of the Institute has been the process during which members of each team discussed each element contained in their strategic plan, with a particular focus on defining the first steps they will make when they return home.

To ensure the quality and effectiveness of the Institute, the NSRC has established rigorous standards for the selection of faculty and the delivery of the program. The composition of the faculty has been analogous to the composition of the school district teams. To be eligible, faculty members need to have a leadership role in a community implementing an effective science program. Their selection is also based on their experience and expertise in both working in science education reform and as a member of the Institute faculty whose responsibility is to both deliver portions of the Institute program and to work with numerous school districts to develop strategic plans.

To assess the impact of the Institution on school district progress in establishing the infrastructure, the NSRC arranged for external evaluations by the Program Evaluation and Research Group (PERG) of Lesley University in Cambridge, Massachusetts. PERG's evaluation of several hundred school districts that have participated in the NSRC Strategic Planning Institutes has indicated that most districts have made significant progress in adopting challenging curriculum, reforming professional development programs for teachers, and establishing efficient materials support systems. Less progress has been made in the areas of assessment and building partnerships with other institutions.

For school districts to make continuous progress on the establishment of the infrastructure, districts need ongoing access to research and best practices, need to participate in a learning network, and need technical assistance to learn how to document their progress and impact. These support strategies will be critical if the nation is to sustain its current investments with districts currently implementing programs.

**Model for Science Academies**:

The NSRC's effectiveness in bringing about change is directly linked to its parent institutions, the National Academies and the Smithsoniah Institution. The Smithsonian has provided credibility and national recognition to the NSRC's work and attracted educators, parents and community organizations, and the National Academies have attracted the scientific community.  The involvement of scientists and engineers is, and will continue to be, critical in establishing quality programs, engaging academic institutions and industry in this important work, developing strategies that will create stability and sustain change, and raising the status of the profession.

**KOREAN EXPERIENCE IN SCHOOL SCIENCE EDUCATION**

***Yung Woo Park and In-Kyo Han***

(Korean Academy of Science and Technology, Seoul 135 –703, Korea)

## I. Introduction:

Science education in developing countries is a fundamental issue to improve the economic growth and the living standard of the countries. In the second half of the $20^{th}$ century, various programs have been created worldwide to support the science education in these countries. Many of the programs, however, turned out to play the role only to emphasis the importance of the science education in developing countries. Korea together with Singapore, Hongkong, and Taiwan are known to be the most successful Asian countries in achieving the goal of high-tech development to the worldwide top level and in improving the living standard. In this respect, to analyze the experiences of science education in Korea is a keenly interesting issue. In this talk, the science education systems and articles, existing problems, environment, manpower for education, science education policy and outsourcing for the science education are discussed. The governmental investment for science and technology in total is approaching to 56% of GDP in Korea recently, which is essential to accelerate the development of science level and economic growth of Korea. In parallel, or perhaps more importantly, it is the spirit of Korean people (as was shown in the Korea-Japan World Cup Football Game held in June, 2002) who are eager to have high level science education, which leads to the astonishing development in relatively short period.

## II. Status of School Science education in Korea:

1. Systems and Articles:

(1) Science curriculum:

Since the second world war, there have been eight times revisions of the science curriculum in Korea. Current Science curriculum and the units are listed in the table below:

| | Elementary School | Middle School | High School |
|---|---|---|---|
| Unit time/ Year | 1st grade: 120 hours | 1st Grade: 136 hours | Common Science: 8 units |
| | 2nd grade: 136 hours | 2nd grade: 136 hours | Physics I<br>Chemistry I<br>Biology I<br>Earth Science I<br>4 units/each |
| | 3rd grade: 102 hours | | |
| | 4th grade: 136 hours | 3rd grade: 136 hours | Physics II<br>Chemistry II<br>Biology II<br>Earth Science II<br>4 units/each |
| | 5th grade: 136 hours | | |
| | 6th grade: 136 hours | | |

The school science education has made remarkable progress with these well planned curriculum revisions. However, it was not sufficient to keep up the current trend of science development since the period of each revision was 7-8 years which is a bit too short. The text books have not been revised well enough to catch up the aims of each revision of the science curriculum. The short period of revision has an advantage of absorbing the new curriculum trend of the advanced countries. And yet, it is also true that we didn’t have enough time to settle down our own model of science curriculum in Korea. The situation was quite different from that of Japan where Japanese could have developed own frame of science education curriculum since 1910. In this regard, we are behind at least 60 years to Japanese science education system. Another tendency to notice is that the number of unit time per year for science education has been reduced approximately 20% recently, which could cause a significant impact to the school science education in Korea.

The School Science education has made remarkable progress with these well planned curriculum revisions.

→ The short period of revision has an advantage of absorbing the new Curriculum trend of the advanced countries.

However, it was not sufficient to keep up the current of science Development since the period of each revision was 7~8 years which is is a bit too short

→ The text books have not been revised well enough to catch up the aims of each revision of the science curriculum

(1) Evaluation system:

Although Ministry of Education in Korea has directed the school teachers to do more experiments in the laboratory for the student evaluation, the reality in school is still to use the examination score in classroom as the major evaluation method. The main reason for such difficulty can be summarized as

(a) to do meaningful experiments, it takes lot of time and effort for school teachers to prepare. Furthermore, the actual experiments are more or less those confirming the knowledge in the textbooks. Such experiments cannot develop creative mind to investigate the unknown phenomena in nature.

(b) there is no standard established to evaluate the experimental works. The evaluation standard for the whole process of experimental works including the experimental design in the very beginning has to be well established. The standard can vary depending on which kind, objective and character of experiments. Thus, one should investigate to establish the appropriate standard of evaluation in each case as soon as possible. Performing experiments, students feel themselves to be the great scientists who actually discovered the phenomena originally.

(c) Like A-level and O-level in England, or basic and advanced courses in Germany, the entrance examination in Korea should be diversified to two levels with appropriate waiting factor depending on the ability of students.

(3) Law for promoting the science education:

The law for promoting the science education in Korea has been established in late 1960s. However, this law has not been revised at all since it was established. As a result, it does not reflect the reality of the science education in Korea at all. Although the law contains (a) master plan for science education and improving the content and method of education, (b) secure the science teacher with proper payment and education, (c) installation of experimental instruments, manuals and science hall, (d) fund raising for experiment, research and scholarship, (e) miscellaneous, all these items have to be applied to the actual class of science education with appropriate modification and support.

2. Environment for science education:

(1) Working condition of science teacher:

The average working hour in class for science teacher in Korea nowadays is 31 hours/week. However, to do experimental education properly, the teaching duty has to be increased inevitably. Furthermore, the average number of students in each class is 50, which is too many to educate the experiments effectively . It is desirable to reduce the number of students in each class to less than 25 (i.e. less than 50% of the present number of students). It means that we have to increase the number of science teachers significantly to carryout the education properly. On the one hand, the science teachers have to self-educate themselves to be prepared for the better education. They have to be capable to improve the condition for doing experiments.

(2) Condition for doing experiment:

Doing experiment for science education is such an essential factor that nobody argues on it. And yet, most of the science teachers agree that the actual experimental education is not properly done in the classroom. It is because of the following reasons:

(a) The experimental education is not taking into account in the evaluation of the university entrance examination. As a result, doing experiment tends to be regarded as waste of time.

(b) In the curriculum, the experimental education is not fully reflected. Usually, it becomes behind the syllabus schedule if one does experiment properly.

(c) There are too many students in each class to do experimental education effectively. Ideally, it should be less than30 students in each class and subgroup unit has to be composed with less than 4 students for each experiment. In reality, there are 50 ~60 students in each class and 6 student in each subgroup.

(d) Safety regulation and chemical waste should be well controlled by law.

(e) The experimental apparatuses are not well equipped in school. Our Government should allocate capital enough budget for schools to purchase the necessary experimental equipments.

(f) The quality of experiments has to be upgraded. The companies in Korea producing science experimental equipments are not good enough to make the high quality apparatuses.

(g) There are no competitive marketing for school to purchase better quality of equipments in expensively.

(h) There are no standard to build laboratory for experiments, so that there are no hood in chemical wet laboratory, no cooling water system, etc. for instance.

(i) Finally, the mind for doing experiment has to be changed. In Korea, experimental education is regarded as doing experiment by students. However, there are experiments demonstrated by teachers as well. Also, the experimental education can be classified as pre-experiment, investigating experiment, confirming experiment, project type experiment or thought (gedanken) experiment depending on each kind of experiment. The computer simulation experiment is becoming more and more important in these days. Therefore, one has to utilize the various way of doing experiment to enhance the efficiency of experimental education.

1. **Outsourcing of School Science Education**:

The opportunity of science education outside school is not widely open in Korea. The outsourcing of school science education can be done either through the exhibition in science museum or through the science contests such as Science Olympiad.

**1. Science museum**

(1) Each local self-government builds science museum which is specialized to the character of the prefecture. By this way, people can look around the local museums throughout the country with not much overlapping.

(2) The science museum in small towns can be a science park which is a play ground for people.

(3) It is important that the content of exhibition should have enough scientific meaning as well as enough elements for events of leisure.

(4) Private companies should support financially and be involved actively in establishment and management of science museums.

(5) Full time working experts should be hired for the maintenance of science museum.

(6) Continuous development of idea and various ways of demonstration is essential to update the exhibition

2. **Science Contest**:

In science contests, the competition and participation in scientific events are the main activities. With the contests, students themselves can participate in the activities, which could not be done in school education. Also, one can select the highly talented students in science through the contests. Each country offers various science contests of its own. At the same, there are several internationally known science contests such as Science Olympiad, International Science and Engineering Fair, EC Contest for Young Scientists, etc. There is another kind of contest called "Cooperative Study and Discussion Contest of Science'. It has several characteristics as following. (a) The topics are given 3 ~ 6 months in advance (b) it emphasizes the cooperative group study rather than individual investigation. Therefore, the team play harmonizing the individual capability maximally is encouraged very much. (c)

Other people's opinion and claim are discussed critically with each other before they are admitted.

## IV. **Concluding remark**:

To improve school science education, we should analyze the tradition of Korean science and technology first and study the updated international trend carefully to internationalize the Korean science education. By this way, we can establish our own model of science education. By this way, we can establish our own model of science education which is in the world wide top level. We should globalize our science education by enhancing the mutual scientific exchange activities. The Korean Academy of Science and Technology (KAST) can play the major role for such international exchange program through the multilateral cooperation with the foreign academies. Finally, our government should raise the fund significantly to support such globalization of science education.

# THE ROLE OF THE ACADEMY OF SCIENCES MALAYSIA IN SCIENCE EDUCATION

***Augustine S.H. One and Omar Abdul Rahman***

(Senior Fellows of the Academy of Sciences Malaysia)

## 1.0 BACKGROUND

### 1.1 Academy of Sciences Malaysia

The Academy of Sciences Malaysia (ASM), was established by the Academy of Sciences Malaysia Act, 1994, which came into force in February 1995. It is a body corporate. It was officially inaugurated by the Prime Minister, Rt. Hon.Dato' Seri Dr. Mahatir Mohamed on 8 September 1995.

The objective of the ASM is "*the pursuit, encouragement and maintenance of excellence in the fields of science, engineering and technology in order to promote the advancement of the art and practice of science, engineering and technology for the development of the nation and the benefit of mankind*".

Membership of the Academy is confined to eminent Malaysians who are regarded by virtue of their respective achievement in the fields of science, engineering or technology as being of exceptional merit and distinction. The Fellows are organized into seven disciplines namely Medical, Engineering, Biology, Mathematics and Physics, Chemistry, Information Technology and S&T Development. To date the Academy has 102 Fellows.

The Academy has embarked and implemented a number of strategies to achieve the established objectives which include the following thrusts:

- Providing advice to the Government on matters relating to science, engineering and technology (SET) which are of national importance
- Fostering a Culture of Excellence in SET in Malaysia
- Assisting in upgrading of technological capability and competency of Malaysian industries
- Promoting public awareness on the importance of SET in everyday life

- Enhancing international collaboration and cooperation

Since its inception in 1995, the Academy has undertaken numerous initiatives and carried out many programmes and activities based on the five thrust areas. In the context of K-Economy and within the framework of National Innovation System (NIS), the Academy as an important component of the national advisory system will continue to play its strategic role in ensuring the continuous and sustainability of the development of science, engineering and technology for national development.

## 1.2 Science and Technology Education

Science and technology has always been accorded high priority in Malaysian education. This is understandably so considering these two areas provide the pool of future technocrats needed by the country for development and industrialization.

The New Economic Policy (NEP) promulgated in 1971 identified science and technology as prerequisites for economic progress and explicitly developed educational strategies to encourage its development. Subsequent national five-year plans reiterate the importance of science and technology as an integral part of the national development strategy. The Prime Minister's speech to the Malaysian Business Council in 1991 (which later became the Vision 2020 policy document)outlined "the challenge of establishing a scientific and progressive society that is innovative and forward looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilization of the future'.

Science and technology also has a social goal – to promote rational analysis and inductive and deductive reasoning as well as imparting values – curiosity, open-mindedness, critical scrutiny and evidence, honesty, respect for others, tolerance, accuracy and precision to name some.

The National Science Education Philosophy states that ‘In consonance with the National Education Philosophy, science education in Malaysia nurtures a Science and Technology Culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and able to master scientific knowledge and technological competency’. In order to realize this philosophy, Malaysia needs to establish an educational system that promotes interest in science and technology right from the moment the children enter pre-school to beyond the day they graduate

The Academy of Sciences Malaysia has carried out many efforts to enhance science education in Malaysia. Since its inception, the Academy has collaborated closely with Ministry of Education and many other organizations in implementing programmes and activities to promote science education.

## 2.0 THE ROLES OF ASM IN SCIENCE EDUCATION

### 2.1 Advisory Role of the Academy of Sciences Malaysia

The Academy has submitted a report to the Ministry of Education Malaysia on “Designing Science Education for Competitiveness: Recommendations on Measures to Increase Student Enrolment in Science in Malaysia”. Among the recommendations put forth by the Academy are the need to review the curriculum especially the conditions of subject choices and also the syllabus of the three science electives. The long-term strategy is also bring science to all and to create the perception that science is within the reach of the majority. The Academy also proposed to formulate Standards for Science Education to provide comprehensive guidelines to shore up the image and status of science education. It was also further proposed that National Council for Science and Technology Education be constituted. The Council, among others is to act as an advisory body to the Government on matters relating to Science and Technology education.

The Academy is in collaboration with the Ministry of Education Malaysia also organized an International Conference on Primary and Secondary Schools Science and Mathematics Education last year together with a National Exhibition on Science and Mathematics Innovative Teaching and Learning Kits. The theme of the Conference is "Science and Mathematics Education: Responding to the Challenges of the K-economy". It gave the opportunities for scientists, science teachers and educators and Government officials in Malaysia and the region to share experiences with international colleagues on the importance of innovative teaching and learning methods. The Conference agreed unanimously that there is an urgent need for an innovative teaching and learning in science and mathematics to be implemented in both primary and secondary schools. It also agreed with the proposal to establish a Teachers Institute for Mathematics and Science Malaysia (TIMS) and to establish a regional network among all science and mathematics teachers, educators and scientists.

### 2.2 Promoting Science Awareness

The Academy Science Awareness Programme was established with the aim to increase awareness and understanding of the central role which science and technology play in Malaysia's economic and social well-being and also to develop a scientific culture in the society. The ultimate vision for the programme is a nation whose citizens are well informed about and comfortable in debating science and technology issues, and whose young people are giving due consideration to extending their formal education in science, engineering and technology beyond the compulsory years of schools. The Academy strongly believes that creating science awareness and instilling a science culture amongst the younger generation are important elements is promoting science education.
The Academy has successfully carried out many interesting and beneficial activities under the Science Awareness Programmes especially to promote and enhance science and mathematics education in Malaysia:

#### 2.2.1 National Science Quiz

The National Science Quiz is a programme targeted for science students aged 16-17- Form Four and Five. The main objective of the programme is to promote science awareness and excellence in science and technology among our students. The Winners of the Quiz also have the opportunity to visit Stockholm to witness the Nobel Prize Ceremony and to visit Sweden and Denmark. By giving such exposure to students it is hoped that it will become an encouragement and impetus for them to strive for excellence in addition to obtaining 'role models' in the area of science.

### 2.2.2 Back to School Lectures

Back to School Lectures is a programme where Fellows of the Academy go back to their alma mater to present lectures on relevant issues on science and technology and also to talk about career development in the fields of science and technology. The Academy also collaborated with the National Science Centre with its 'Saintis ke Desa' programme. The main objective of the Back to School children. It is hoped that this lecture will provide a better understanding and awareness among young Malaysians of the importance of science and technology and provide incentive for them to pursue careers in these areas.

### 2.2.3 ASM Lecture Series: Petrosains – ASM 1998/1999 Lectures:

The ASM Lecture Series is designed to inspire enthusiastic interest in science, engineering and technology through an information-packed programme, intriguing demonstration and spectacular special effects. It features lively talk, attractive visuals, engaging multimedia and participative sessions where the audience is physically and mentally involved. It is principally aimed at an audience of young people at the age group of 15-16 years old. The mission of the lecture is to challenge and inspire young people to pursue careers in science, engineering and technology and to stimulate them to become leaders in these fields. About 10,000 students and 3,000 teachers benefited from the programme through its two years of implementation. Based on the feedback from the students and teachers involved, the programme was perceived as educational entertaining, informative and managed to meet its intended objectives.

### *2.2.4 Seminar to Evaluate the Science Education Quality Improvement Project (SEQIP)*

SEQIP or Science Education Quality Improvement Quality Project was initiated from the Indonesian side and is supported by the German Government as part of its development cooperation. The goal of the project is to improve the quality of science teaching through an integrated approach. The project has developed its components in the try-out phase 1994-1996 and was able to prove that significant quality improvement in science teaching was achieved.

The Academy feels that SEQIP is one project which can be adapted to Malaysia's education system because the teaching materials are in Bahasa Indonesia and the curriculum is almost similar to ours and also the teaching kits used local materials. Furthermore the system has been tested and proven successful in Indonesia. Therefore adapting readily available teaching kits which have been proven effective is more practical, cost-effective and time-saving. The seminar concluded that the SEQIP system was found to be good effective in improving the quality of science teaching and learning and can be adapted for implementation in Malaysia's education system.

### 2.2.5 Workshop to discuss the proposal to establish teachers institute for mathematics and science Malaysia (TIMS)

A workshop to discuss the proposal to establish TIMS was organized in collaboration with the Ministry of Education Malaysia. The workshop suggested forming a Pro-tem Committee comprising of Academy of Sciences Malaysia, Ministry of Education and universities to initiate the establishment of TIMS.

### 2.2.6 Estidotmy

"Estidotmy" is a publication on science and technology topics targeted to primary and secondary school students. The project is funded by the Ministry of Science, Technology and the Environment and the Academy acts as the Project Manager. It is published as an insert in Utusan Malaysia paper. Based on the response from the readers, Estidotmy is a good vehicle to disseminate information on science and technology and since it is distributed with the newspaper, the coverage is far and wide.

### 2.2.7 Science Camp

Rakan Muda Sains/Rakan Esti is a flagship programme targeted for the youth with a vision to produce a generation of youth who is scientifically literate, knowledgeable, dynamic, competitive, healthy and able to contribute to the progress of science and technology for the development of the nation. There are many different modules of activities carried out under this flagship using a thematic approach.

### 2.2.8 Enhancing Excellence in Science and Technology

The inculcation of a scientific and technological orientation and values at an early age will create the appropriate attitude and mindset for the development of science and technology. The younger generation should be given the vision that science and technology are the drivers to enhance national competitiveness to sustain economic growth towards achieving the goals of Vision 2020. With realization and awareness on the fundamental importance of science and technology, it is easier to inculcate the culture of excellence to those fields. There are no short cuts to excellence. The inclusion of the culture of excellence has to start early. It has to begin with our young people for they are the very foundation that determines the future success of our nation. On a global scale, in the year 2000, young people between the ages of 10 and 19 comprise 20 percent of the human race – 1.2 billion people – it is not an exaggeration to say that how effectively we navigate the shoals of adolescence will be a crucial element in how well all of humanity weathers the coming challenges of the next century.

The flagship programme for the Academy under the promotion of culture of excellence is “Achieving Excellence in Science: The Nobel Path”.

### 2.3.1 Achieving Excellence in Science: The Nobel Path

There are various activities carried out under this flagship and the activity targeted to school students are the ASM Public Lecture by Nobel Laureates. The students are given the opportunity to listen to the lectures given by the Nobel Laureates on the implications of the scientific research or findings on the public in general with the hope to spur the interest of the students in science and technology and also to provide a role model for them.

### 2.3.2 Malaysia Toray Science Foundation (MTSF)

Malaysia Toray Science Foundation is a non-profit making foundation registered with the Malaysian Authority with the objective of contributing to the progress of science and technology in Malaysia. The Fellows of the Academy are the committee members of the foundation. One of the foundation activities is the awarding of the Science Education Prizes to recognize creative and innovative contributions to effective science education in junior and senior high schools.

## 2.4 International Perspective

In promoting and enhancing science education the Academy takes advantage of its strong international linkages with various regional organizations such as the ASEAN Council of Academies of Science and Engineering (ASEAN-CASE) and international organizations such as the Inter-Academy Panel(IAP) and the International Council for Science (ICSU). The Academy collaborated with ICSU to organize the International Conference on Primary and Secondary Schools Science and Mathematics Education 2001. The Fellows of the Academy also are actively involved in science education activities internationally.

## 2.0 Conclusion

Science has been accepted as a foundation of advanced technology and for understanding of nature. Scientific methodology could enhance our mode of thinking and way of life. Improving science education is part of a systematic education reform. Within the larger education system, science education can be viewed as a subsystem with both shared and unique components. The components include students and teachers; schools with principals, policy makers; teacher education program in colleges and universities; textbooks and textbook publishers; communities of parents and of students; scientists and engineers; science museums; business and industry; and legislators. The Academy of Sciences Malaysia thus provides the unity of purpose and vision required to focus all of those components effectively on the important task of improving science education for all students in Malaysia.

The nation cannot meet the challenges of the future unless today's children have a better understanding of the world and how it works. Science education which provides literacy in science, mathematics and technology is not an option for the citizens of the $21^{st}$ century.

## SCIENCE EDUCATION AT SCHOOL LEVEL IN NEPAL

***D. Bajracharaya and K.M. Shrestha***
(Royal Nepal Academy of Science and Technology,
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Nepal is a small Himalayan country with an area of 14 7181 sq.km. Nepal borders with the People's Republic of China in the north and India in the south, east and west. The country is divided into five development regions. Each development region is made up of many districts. There are altogether 75 districts.

School Education system in Nepal comprises of five years of primary education (grade 1-5), two years of lower secondary education (grade 6-8), two years of secondary education (grade 9-10), and two years of higher secondary education (grade 11-12).

Science is a compulsory subject only at lower secondary (grade 6-8) and secondary (grade 9-10) levels. At primary level (grade 1-5), science is being taught as Environmental science and Health education. At higher secondary level (11-12) science is not compulsory. School science both at lower secondary and secondary levels is taught as general science which include Physics, Chemistry, Biology, Astronomy and Earth Science.

In Nepal, there are two categories of schools. Private and Public schools. Private Schools are those which do not receive regular government grants. According to the available data (1999) there are 25522 primary schools, 7276 lower secondary schools and 4082 secondary schools including private schools. The number of private schools are 5711 in primary level, 3665 lower secondary and 2616 secondary. Most of the private schools are concentrated in urban areas and in some district headquarters. There is increasing trend of schools at all levels.

Science Education Project (SEP) was established for the first time in Nepal on Nov. 18, 1982. The aims of the science education project was to improve the quality of school science education through upgrading science teaching skills and science facilities. However, the major achievements of science education project were limited to the establishment of one national Science Education Development Centre (SEDEC) at Sanothimi, Bhaktapur and 25 Science Education Development Units (SEDU) at 25 selected districts throughout the country. The other achievement of SEP was the delivery of science equipment and chemicals to the selected 700 schools and 25 SEDU. SEP also gave opportunities to undergo training to many school personnels.

However in 1992 SEDEC was converted into Secondary Education Development Project (SEDP). The overall objective of the SEDP is to support the HMG's development goals by producing middle level manpower for the country as well as the quality inputs for tertiary education by improving the quality and efficiency of secondary education.

Recently secondary school science curriculum has been reformed with emphasis on cognitive development and student's active participation in school science teaching learning process. Thus reformed school science curriculum has envisaged the following objectives which the students will develop after the completion of secondary level education.

- To explain the importance of science and develop competence in applying knowledge and skills for the solution of problems in daily life.
- To develop a basic knowledge of scientific concepts principles and laws and draw conclusions from them.
- To develop the skill of observation and inquiry necessary for learning about science.
- To identify resources available in the environment and describe their characteristics by using scientific skills.
- To explain natural phenomena and their effects on the environment.
- To explain the relationship among science and human life.
- To classify, sketch and describe given specimens and demonstrate systematic understanding of scientific experimentation.
- To develop the ability to understand the underlying unity of various branches of science.
- To appreciate scientific development and develop curiosity towards scientific research and
- To develop the knowledge of science necessary for further studies.

In order to facilitate such teaching learning process in secondary school science, (Ministry of Education) has distributed necessary school science instructional materials in the form of equipments and chemical to selected schools throughout the country. Unfortunately many of the schools that received the equipment and chemicals could not use properly in teaching learning process because of lack of skill manpower and lack of positive attitude on the part of school administrator as well as school science teacher. School science teachers did not use those science materials because they were habituated in teaching science by lecture method only.

In spite of all these shortcomings, there is gradual increase of student's enrolment at secondary school. In order to cope with the ever-increasing number of students, more teachers need to be recruited and trained to meet the demands.

Although science curriculum demands school science teachers to be more open minded and accomplish teaching learning process with student centered approach the science teachers tend to run science classes only by lecture method depending totally on the written text available in the prescribed science text book only. Some of the topics that are covered is given in the box.

| | |
|---|---|
| Grade 1 – 5 | Environmental Science and Health Science |
| Grade 6 – 10 | Physics, Chemistry, Biology, Astronomy and Earth Science |
| Grade 10 – 12 | Physics, Chemistry, Biology, Mathematics |

Science teachers often see science as a subject that requires learning to simply be a matter of knowing, being able to use the right formula, or being able to balance equations. School science teachers fail to arouse curiosity and motivate to observe scientific principles in and around our environment.

In order to update the quality of secondary school science teachers, MOE has been imparting training to school teachers. In this regard, SEDU at 25 districts and

SEDP at the center has played the key role in training science teacher. School science teacher are encouraged to join pedagogical training for fixed duration. However, there is always shortage of trained teachers in all subjects including science at all levels.

Shortage of trained teachers may be due to various reasons. Many trained teachers leave the teaching job and join other profession which pays high salary and provide many benefits. Many trained science teachers leave job because of professional dissatisfaction.

MOE has also reformed School Leaving Certificate (SLC) examination system in order to match the recently reformed school curriculum. However, the reformed examination system is found to be largely cosmetic. The results of SLC board examination shows large proportion of student population have failed to pass the school leaving certificate (SLC) examination.

Recently MOE has introduced separate practical examinations system for secondary science students at the end of SLC examination. However, almost all schools except few do carry our science activities in the teaching learning process as mentioned in the school science curriculum.

In spite of all these changes the condition of school science has not improved significantly as envisaged in the school science curriculum. All these short comings are partly due to the over ambitious school science curriculum, inadequate training to science teachers, inappropriate selection of science teacher trainer, improper examination system and inadequate supervisory system.

The Royal Nepal Academy of Science and Technology has taken many measures towards the improvement of science education. A few of these are displayed in the box.

SCIENCE POPULARIZATION PROGRAMS OF RONAST

- Publication of Popular Science Magazines
- Radio Programs (AM/FM)
- Science Exhibitions
- Quiz Contests
- Essay Competitions
- Meet your Scientists: an Interaction Program
- Presentation of Awards and Prizes

The future plans of RONAST is towards the establishment of a Science Learning Centre with the following objectives:

- Enhance Science Literacy
- Explain Scientific principles to Public
- Propagate Indigenous Knowledge on science and Technology

The programmes of the Science Learning Centre involve:

- Indoor and Outdoor Exhibitions
- School Based Activities
- Media Based Programs
- Mobile laboratory and Exhibitions
- Workshops, Teacher Training and Interaction with
- Media persons, Planners, Politicians

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# SCIENCE EDUCATION CONDITION IN AFGHANISTAN

***Abdul Khalil***

(Academy of Science of Afghanistan, Kabul, Afghanistan)

I believe that "Asian Regional Seminar on Science Education" is an opportune useful and necessary work. It would be perfectly proper if existing gathered to call a grand association of outstanding learned persons in science and technology field. Therefore I have the honor to participate in this session.

Honorable scientists we have gathered here, in handsome historical capital of great India to find effective methods and ways of science education, and to distinguish better and new models of learning.

As we know effective usage ways and methods of contemporary science and technology output in the world, especially in development countries is an important issue.

The present time majority of Asian countries included region countries consist developing countries. Therefore we have to find better and effective methods and ways for teaching and learning of science in schools for rapid growth of science and technology in the region which is the main objective of the seminar in that is very important and worthy for all.

Respectable wises certainly you have expected me to discourse about my activities and new initiatives and science education specially for development region countries, but while most regret that I can not reply positive due to within over two decades barbarously war in Afghanistan there are destroyed almost all of the cultural social and economic infrastructures in our country.

Therefore at the present time we have a lot of difficulties in various areas including training and civility affairs. During the war about 70% of educational institutions had demolished. Most of the school buildings, laboratories and teaching materials had been destroyed. In 2002 year 4.5 millions children had possessing conditional to go to school, but in cause of different reasons there were only 3 million of them found chance to go to school.

Besides that at the present time there is shortage of professional cadres, teaching materials and equipment, for example, there is shortage of 28815 teachers, 2500 school buildings, 1125000 benches and tables and 15.5 million teaching books in running year. Although in Afghanistan we have in free of cost education system but because of nonexistence schools in most of the villages majority of the people are dyslexic. Therefore mostly people are busy infield of the cultivation and husbandry. In addition during the war years and immigration, most of the children could not go to schools and they have deprived from the blessing of the literacy. During Taleban regime, which lasted five years, the schools for girls were closed and boy's schools left open just to show education is available for Afghan children. At that time, teaching of science subject decreased and religious subjects have been added..

Also in higher education we have a lot of problems because of 23 years war and political problems, most of the high-educated people and university teachers left the country. In result, university and colleges faced with shortage of professional teachers. Therefore inexperience teachers were hired which effected and lowered level of education. In addition of shortage of teachers, high education institution destroyed, all equipment and machinery and buildings mostly ruined. Presently cultural institutes like social service and economic institutes need to be rehabilitated. For reconstruction of the above institutes a considerable fund is needed. For instance for rehabilitation of schools and other educational institute only we need $876 million.

Afghanistan is not able to reconstruct these institutes without help of other countries. Academy of Science of Afghanistan, which is recently established, also effected by the war. This scientific research center in addition to lose some of his knowledge, lost its laboratories, instruments and other facilities too.

During more than 20 years, the Academy of Science of Afghanistan had not scientific contact with abroad. Therefore we have not received any new information about the progress and development in science and technology within maintained years.

From above explanations it is clear that at the first of all we need to rehabilitate our entire social, cultural and scientific research structures. At the same time by discernment of problems we have to find the ways and methods for reconstruction and social-economic development of country.

At the present time we are continue to work on the maintained problems, for instance there are presented specified layout about teaching curriculum in our schools such as we have to create unique teaching curriculum proportionate to learning posture of Afghanistan and unnecessary things should be eliminated. We have to provide our teaching curriculum in view of promotes of science and technology. We have to exactly accounted organic relationship between before schools (kindergarten) and after schools (high education) periods. We should do reflect new information about science and technology in our teaching books. We must to take boy schools our society necessary knowledge about acute world's problems such as war, drug and international terrorism. In addition there is existent other difficulties too, some of which as following:

- Most of the teachers have low level professional knowledge
- Because of the non-existence facilities practical works are limited
- There is not specialty education in Afghan common schools. Education based mainly on common system.
- For the children who grow in foreign countries required special schools in foreign languages with standards international teaching curriculum. Because they are trained in various cultures and they can not utilize national languages.
- For the children utilization of the science and technology incomes are limited, for the most of them it is impossible because most of the people do not have even TV. Therefore scientific ideas in our society are much elementary, so modern ideas are not divulged yet.

According to above explanations it is clear that at the present time Afghan society located in special situation.

We would not compare cultural, social, economic and learning conditions of Afghanistan with other countries. According to specific condition our country at the present time we have to rehabilitate our entire field including learning system. We need to establish scientific relationship with other countries for utilization of knowledge incomes and experiences.

Although world community directly or indirectly through UN institutions promised to assist our people in rehabilitation and on these lines has gotten some practical steps, which we appreciate, but our difficulties are so much that accomplished works are nearly insensible, and effective results conceived are not satisfied. To use this opportunity I want to fixed on the mind that our expectation from the international community, other benevolent institutions and even charitable persons do not forget our people, whom the war signs and adversity on their faces available. We need seriously and effectively necessary assistance for our community, because of that on the future Afghan scientist also will have key role like scientists of other countries in useful research for convenience of human community.

At the end I want to thank for organizers of this magnificent scientific seminar, specially from Honorable Professor V. Krishnan, Vice President (Science & Society) that he has consequent of this seminar for good future of human life and especially for improvement of life condition of poor and needy communities.

# SOME RECENT PAKISTANI INIATIAVES

***Riazuddin***
(National Centre for Physics, Quaid-I-Azam University,
Islamabad, Pakistan)

I have organized my talk with two parts:

1) School education for the underprivileged
2) Higher Education

These are the 2 areas which Pakistan has taken recent initiatives.

## I.A Madarsah Education:

One avenue available to underprivileged is Madarsahs (seminaries) which have a long tradition in Indo-Pakistan subcontinent. Madarsahs are supported entirely by donation, which come from small traders and low income group. The rich generally do not contribute Madarsahs are fulfilling a great social need. They take care of the poorest of poor, who cannot even properly feed their children, what to speak of sending them to schools. Madarsahs provide free lodging and boarding and education. However, this education is only in religion and as such is of limited scope. Thus students coming out of Madarsahs have only a limited scope for earning their living. What is needed is to broaden the scope of education the Madarsahs provide. The government of Pakistan is setting up a separate board for Madarsahs which would look after their curricula and include subjects like arithmetic and science. Here generation of experimental materials and learning modules for science education will be needed. May be here we can benefit from the seminars of the type being held here in Delhi.

## B School Education in Rural Areas:

Majority of population live in villages and most of them are underprivileged. Generally a working farmer has no incentive to send his children to a traditional school; he would rather engage them to help him in tilling the land. His attitude towards education need to be changed. Thus a different type of approach and curriculum is needed here. This does not mean that a son of a farmer should remain a farmer. In fact one of the greatest positive impact of education has been to destroy social determinism: son of a cobbler may not become cobbler. The only thing is to provide him an opportunity for education so that he may become a medical doctor, engineer or scientist or adopt some other profession. But what is needed here is that this is urge for education should arise from local environment. He should learn

(i) something on agriculture, how plants grow

(ii) some skills

(iii) arithmetic to enable him to learn bookkeeping

(iv) some geometry, not the sums, but figures – circle, squares, rectangles etc. and to calculate perimeters, areas and volumes etc.,

(v) advantage in using tools which science has created over the years. Some simple observations like coming to school on a bicycle is a quicker and efficient way to travel and comparatively long distance. It may arose his interests in machines and about mechanical laws which govern their working.

(vi) Importance of sanitation and cleanliness: Lack of cleanliness breed germs which cause diseases. May be this will arose his curiosity in learning more about them and Biology.

When he becomes interested in learning, he can go to formal school for further education. Even if he does not go for it, he will be of some help to his family and community. Here also some learning modules were required. A working group has been set up for this purpose.

**II Higher education:**

There is an intimate relationship between school and higher education; they influence each other**.** Until recently the decision makers were brainwashed by external advisors, in particular from the World Bank, to concentrate on school education. This was done at the cost of higher education. Not only higher education did not progress, but it also destroyed the quality of school education for lack of good teachers which higher education produce. Pakistan’s higher education suffered from four deficiencies:

1. Its small scale: It is small in whatever way, you look at it. Only 140,000 students out of a population of 140 million are enrolled in Universities; Pakistan spends about US $1000 per university student per year, which is

surely smaller than even some of the other developing countries spend; small number of qualified faculty, there are only 2700 science Ph.Ds; research out is meager; Pakistan's share of scientific publication was only about 0.08percent in 1994.

2. Lack of quality: its outputs – graduates and research - are generally below international standards.
3. Absence of synergy between higher education and research training; by and large there is no tradition of graduate schools.
4. Lack of built-in institutional responsibility and merit based incentives.

Realising this, the government of Pakistan set up a task force on higher education and a study group on science and technology. They made certain recommendations for the improvement of higher education. To prepare an implementation strategy for the recommendation, a Steering Committee for Higher Education was set up. The Steering committee has suggested restructuring of universities for which the necessary legislation is in progress. The main recommendation of the Steering Committee are

1. Separation of Governance from Management and to provide an enabling environment for Faculty to bring out their best in teaching and research. The governance is based on 3 principles. Accountability, Transparency and Participating role of Faculty in governance.
2. Quality: In the last analysis, the quality depends on quality of teachers. A major effort has been proposed for Capacity Building of Faculty, involving their training and retaining with respect to subject knowledge improvement and pedagogical and communication skills. Linkages with R & D organizations, industry and international research centers have also been proposed.
3. Ph.D. Programs: Major problem is shortage of qualified Faculty. To remedy this as a short term strategy, foreign Faculty will be hired, while for a long term strategy a Ph.D program is proposed to train about 500 Ph.D's in next five years, some of which (about one fifth) will be sent abroad (for entire training), some will be trained thoroughly sandwiched program and the rest will be locally trained.

4. There will be incentives for starting graduate programs leading to Ph.D degree in local universities. There will be graduate and research management council in most of the universities.
5. To maintain quality, a tenure track system of appointments will be introduced. The Faculty coming through this system will get much higher salary but has to show their work before they get tenure.

To oversee these reforms, Pakistan Government has created Higher Education Commission handed by Dr. Alta-ur-Rahman. This replaces the University Grants Commission (HEC) which was simply a post office for distributing funds from Federal Government to the Universities. HEC will be a funding agency which will distribute two types of funds; need based and merit based. The universities who show better productivity will accordingly get more funds. The HEC will also ensure that quality is maintained in higher education.

# SRI LANKAN EXPERIENCE IN SCHOOL SCIENCE EDUCATION

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**INTRODUCTION**:

The educational process in Sri Lanka took in its present form during the foreign colonial occupation of Sri Lanka in the latter part of the twentieth century. In particular the occupation of Sri Lanka by the British from 1796 to 1948 provided the foundation to organize schooling in Sri Lanka. The Education Ordinance of 1931, with periodic amendments from time to time, still continues to provide the basic legal frame-work for the continued development of the school system in Sri Lanka. The British colonial administrative system developed two types of schools: the higher status schools which imparted education in the English medium, were largely centered around urban city centers (and provided 13 years of schooling from age 5 to 18) and the lower status vernacular schools which imparted education in the local languages but were largely primary schools. The class distinction became even more marked since the English medium schools levied considerable tuition fees and were therefore accessible only to those who could afford such an expenditure for their children.

A Royal Commission in the forties laid the pathway open for increased accessibility and liberalization of the gateways for school education in Sri Lanka. The recommendations included proposals to provide education free of charge to all children from the Kindergarten to the University; another proposal was the change in the medium of instruction to the mother-tongue of sinhalese/tamil. The result of the adoption of these proposals, about fifty years ago, was the opportunity afforded to large numbers to study free of charge in their own mother-tongue up to the University level; the school going population increased by leaps and bounds and the Government expenditure on school education sky-rocketed since most schools opted to join the free education scheme promulgated by the Government with only a small number of (largely Christian) schools opting to become private and fee levying. Though at tremendous cost, these far reaching educational changes resulted in more equity and equality amongst a wider segment of the population. Equal Education for All became the goal. The literacy rate of Sri Lanka gradually rose to the region of 86-88%.

However, it has to be noted with regret that the funds made available for education have not kept pace with modern technological and scientific developments due to other demands for the scarce resources available from the national exchequer. Consequently, only 3.8% of the GDP is presently allocated for education of which only 0.4% is provided for higher education at tertiary level. Financial provisions in terms of such percentages for all types of education have decreased over the years since that is considered as a social overhead and not as an invaluable investment. The financial demands of the ethnic war we have been fighting in a useless and unprofessional manner over the part 2 decades have aggravated the situation even further. It is hoped that the current peace efforts on the ethnic front will shortly enable this unsatisfactory situation to be corrected early.

The transfer of the management of the so called "Assisted Schools" from largely religious based management to the government in 1960 for political reasons increased the degree of politicization in the Sri Lanka educational system by leaps and bounds. Regular transfers of teachers, often at the request of the local politician, has brought in a very unsatisfactory degree of influence of politicians that has clearly proved detrimental to the maintenance of quality educational standards in the country.

A three tier school system exists at present as part of the educational scenario, which by itself has undergone considerable change from time to time due to governmental fiats and political interference. These are: Primary (Year 1 to 6); Junior Secondary (Year 7 to 11); Senior Secondary (Year 12 to 13).

The thirteen year school cycle includes the General Certificate of Education (Ordinary level) Examination at the end of year 11 and the General Certificate of Education (Advanced Level) Examination at the end of Year 13.

It has however to be recognized that despite considerable funds being invested on school education by successive governments, especially after independence, severe disparities still exist between urban and rural schools with rural schools being less advantaged especially in the provision of science laboratories and the shortage of qualified teachers. Many Science graduates produced by the Universities, though in ever-increasing numbers, are not attracted to the teaching profession, particularly because the remuneration and social recognition are not very satisfactory. There are serious disparities between schools within the same district even in urban areas. Some are prestigious schools, which are well resourced and also getting high caliber students through admission and national scholarship tests while others are deprived schools which are the inevitable preserve of the lower socio-economic groups.

The total number of schools in the country is about 11,000 of which 97% are run by the Government. However only about 2500 of these provide classes upto G.C.E. (Advanced Level). Only about 575 of these provide science education at advanced level. There is a very good gender mix. A very discriminatory form of University admission based on proportional selection over the past three decades has ensured that there is really no need to improve the educational facilities in rural area schools especially in relation to higher cost science education.

Although in terms of the law, since the take-over of assisted schools by the government in 1960, no new schools can be established in Sri Lanka, a very noteworthy and unwelcome development going completely against the principles of equity and fair-play has nevertheless been the establishment of so called “international schools” in all parts of the country: these are profit making companies in the form of international schools authorized as businesses by the Registrar of Companies coming under the Ministry of Trade. Many of these schools teach Science and cater for foreign examinations and are not under the control of the Ministry of Trade. Many of these schools teach Science and cater for foreign examinations and are not under the control of the Ministry of Education. They charge very high fees and are naturally patronized by the super rich and the new rich including politicians starting with the highest in the land. This dichotomy has turned out to be a very unsatisfactory development that has to a considerable extent gone contrary to the noble vision of equality for all in educational provision.

## DEVELOPMENT OF SCIENCE EDUCATION IN SRI LANKA

The development of a more widespread teaching of Science in Sri Lanka received an impetus only about 50 years ago around the time that Sri Lanka received independence from Britain. The development of Science education was relatively slow with a widespread inequality in the availability of teachers and laboratories to provide a sound education in the scientific disciplines. With universal franchise from 1931 and independence in 1948, political pressures came to be exerted on the system with a populist desire to make science education more extensively available to the rural student. Free education coupled to education in the mother tongue, which increasingly came into vogue in the nineteen fifties provided additional impetus to these political pressures. However, lack of adequate teachers, resources and finances no doubt had a curtailing influence on providing adequate science education to all. Even in the twenty first century the situation still remains as a considerably acute problem.

In 1972, a political decision was taken to adopt a common curriculum with Science as one of eight subjects in all junior secondary schools in the country. Consequently, the teaching of science disciplines (such as Chemistry, Physics, Botany and Zoology) as individual subjects in junior secondary schools came to a stop resulting in a lowering of the scientific knowledge imparted to students of Year 11 in the few schools (that were imparting science education in the Ordinary Level classes up to that time) but with a raising of the scientific knowledge imparted in ALL the remaining 10,000 schools. The gap between the scientific knowledge acquired by students of Year 11 and that required in individual scientific disciplines by students of Year 13 therefore windened considerably. This has no doubt presented considerable problems to the cause of imparting an effective science education at the senior secondary level in Sri Lanka. Making all Sri Lankan school children more science literate has thus been achieved but at the expense of the higher level of scientific knowledge, as earlier existed, amongst those who aspire for science education in senior secondary schools. In the revised curriculum, the teaching of Science commences as part of the subject of Environment in the integrated syllabus. This type of leveling down the imparting and acquisition of knowledge has happened both in scientific disciplines as well as in the teaching and learning of English.

## MEDIUM OF INSTRUCTION IN SCHOOLS

Provision of education, particularly in schools, ONLY in the mother tongue (Sinhalese & Tamil) has been a characteristically significant educational policy in Sri Lanka for the past 40 years. Simultaneously, the accent on the need for a knowledge of an international language (English in the Sri Lankan context ) has been downplayed for political reasons in an apparent attempt to provide equal opportunity and access for education for the rural child vis-à-vis the urban population. Any degree of competence in English, though a compulsory subject at the GCE (Ordinary Level) Examination, is for many years not necessary for any higher educational programme. Consequently, we have in Sri Lanka, a highly literate population who, however, for no fault of theirs, have not been sufficiently motivated to acquire competency in English, so necessary for many vocations in life. Realization of this dilemma has occurred a little too late in Sri Lanka's educational scenario: today, we therefore have a rural population who realize the need for English which they cannot adequately obtain with any degree of quality or accuracy due to the grave paucity of English teachers. Short sighted political decisions which were apparently intended to avoid marginalisation of the rural and underprivileged sector have virtually boomeranged on that very sector; however the urban sector is better able for cultural and historic reasons to obtain this much needed competency in English. It is ironic though not surprising to observe that even for employment in the state sector, anybody having competency in a second language such as English, is obviously at an advantage compared to a person competent in a local language only. The vastly growing so called International Schools have aggravated this dichotomy even further.

## SCIENCE EDUCATION IN ENGLISH

Due to the lack of adequate competency in English, secondary school children as well as university undergraduates have insufficient and inadequate reading and reference material in all scientific fields. A few text-books have been produced in the local languages to cater to this need but these are grossly insufficient when one considers the wealth of material that is necessary for a complete education and which is in fact produced in the local languages at the post-secondary level. Science education in Sri Lanka at the secondary and tertiary levels in Sri Lanka has therefore been adversely affected. Attempts made by the Government of Sri Lanka to undertake the translation of renowned English text –books were abandoned many years ago when it was realized that the exponential growth of scientific knowledge cannot be matched by such costly and expensive endeavors in any satisfactory or pragmatic manner.

# SCIENCE FOR EVERYBODY

## Fondo de Cultura Económica

***J.L. Moran Lopez***
(Institute for Science and Technological Research,
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Science for everybody is a collection of monographs written by active scientists, mainly, for high school and college students. It is very successful programme with a large number of copies being sold. The best seller is a book in Astronomy with more than 90,000 copies sold.

This is a Mexican programme to

- Disseminate the scientific knowledge in Spanish.
- Improve the science education of young students.
- Increase the number of students in scientific areas.
- Actualize high school and college teachers in scientific research.
- Offer to the general public monographies of actual themes of research.

A brief history of this venture is as follows:

The collection started in 1986 under the name ***Science*** from Mexico. After ten years and to invite authors from other Latin-American countries, the name was changed to ***Science for Everybody***. The project is supported by the Ministry of Public Education and the National Council of Science and Technology.

The authors of the monographs must be an active scientist (in Mexico to belong to the National system of research). The authors are required to submit a project outlining the topic, index an abstract, at least a chapter and his curriculum vitae. The book contains between 112 to 176 pages with a maximum of 35 figures. An Editorial Board consisting of ten well recognized scientists reviews these proposals from authors and final approvals are granted. After approval, the authors sign contract with the editorial house which consists of terms of delivery and royalties. The scientific areas and number of titles are given in the box.

| Areas | Titles |
|---|---|
| • Astronomy | 15 titles |
| • Biology | 58 titles |
| • Earth Sciences | 14 titles |
| • Physics | 57 titles |
| • Engineering | 2 titles |
| • Mathematics | 7 titles |
| • Chemistry | 18 titles |
| • Others | 18 titles |
| Total | 189 titles |

Among the 195 authors, there are 162 men, 33 are women. The authors include from other Latin American countries and the distribution is as follows; 7 authors from Argentina, 2 from brazil, 1 each from Costa Rica and Cuba.

General National contests are being held under the banner '***Science for Everybody***'. It calls to read the books of the series and to write reports and essays. The readership is categorized according to different age groups.

- Category A (12 to 15 years old): Short abstract and opinion
- Category B (16 to 18 years old): Evaluation paper
- Category C (19 to 25 years old): Essay
- Category D (High school teachers): Didactical essay
- Category E (Technological Universities): Prototypes

In the first contest held in 1989, a total of 2868 reports have been received, of which 995 were from Category A, 1601 from Category B and 272 from Category C. The distribution of areas in which reports were received under different categories is shown in the box:

| Areas | Category A | Category B | Category C |
|---|---|---|---|
| Astronomy | 62 | 267 | 273 |
| Biology | 87 | 457 | 291 |
| Physics | 77 | 470 | 262 |
| Chemistry | 32 | 301 | 103 |
| Geophysics | 6 | 30 | 21 |
| Others | 17 | 76 | 45 |
| | Total | 2868 reports | |

The second contest was held in 1990-1991 and as can be seen from the number of reports received; there was an encouraging response. A total of 5021 reports were received in various categories, 2450 reports were received in Category A, while 2151 and 420 reports were received in Category B and C respectively. The gendership of the participation in these contests revealed an interesting trend in a sense there were more women (2723) than men (2298).

There has been a steady increase in the participation in these contests and it is rewarding to present the results of sixth and seventh contest held in 1999-2000 and 2001-2002 respectively.

| Category | 1999-2000 | 2001-2002 |
|---|---|---|
| A | 7,337 | 24,460 |
| B | 12,383 | 35,410 |
| C | 1,007 | 3,504 |
| D | 41 | 237 |
| Total | 20,768 | 63,611 |

It is to be pointed out that a Category E was introduced in 2001-2002 contest to include from students of Technological Universities. 275 students under this category participated in this contest.

The participation in the different areas in the contests held in 1999-2000 and 2001-2002 are given in the box:

| Area | 1999-2000 | 2001-2002 |
|---|---|---|
| Astronomy | 2,375 | 7,088 |
| Biology | 6,719 | 21,126 |
| Earth Sciences | 1,759 | 4,826 |
| Physics | 4,937 | 14,615 |
| Engineering | 112 | 451 |
| Mathematics | 373 | 1,010 |
| Chemistry | 1,357 | 4,756 |
| Others | 3,118 | 9,609 |

It is of importance to note that among the participants in 2001-2002 contest, 52% belong to female while 48% constitute male. As one can notice, there has been an increasing trend in the participation of the contests over the period. This indicted the high popularity of the contests and a greater awareness of science and its importance in the present day context among the public in different age groups. There has been a welcome sign in a sense that the contest is in the process of internationalization. The other Latin American countries, Cuba and Chile are going to implement the Mexican model of ‘Science for Everybody’.

The organizing institutions in Mexico are

- Ministry of Public Education (SEP)
- The Editorial House, Fondo de Cultura Económica (FCE)
- National Council of Science and Technology (CONACYT)
- National Association of Universities and High Education Institutions (ANNUIES)
- Mexican Academy of Sciences (AMC)

# EXPLORATORY SCIENCE CENTRE AND CHILDREN SCIENCE MOVEMENT

***V.G. Bhide***

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I have decided to talk on this occasion on Exploratory Science Centre – a new innovation in science communication and on Children Science Movement, a movement which we recently launched in Maharashtra, which the leading scientists in the country consider nationally as important as the Quit India Movement launched in 1942, for a variety of reasons. Firstly, I believe children are the precious treasure of the country and are the real hope and future of the country. Secondly, because the emerging era marks a paradigm shift in the history of human civilization in which science and technology will increasingly shape our view of the universe, pattern our sojourn on this planet and mould our ultimate destiny and pose daunting challenges and throw numerous opportunities for the younger generation to seize.

From time immemorial, the goal of education has been to liberate the mind. Although the essence of the goal of education has remained the same, but over the years, it has acquired new facets and greater dimensions. In the contemporary world, the goal of education can be articulated as liberation of the mind, upliftment of the soul, empowerment of the hands and stimulation of the brain to invent and innovate. In a sense education stands for integral development of the individual – mental, physical, spiritual, etc., and through the development of the individual, the development of the society of which he is an integral part. The liberation of the individual essentially implies his liberation from ignorance of who he is? What the universe or surrounding Nature is? And how he can usefully interact with nature or his surrounding for his own benefit and for the benefit of the society.

Although the goal of education has remained essentially the same, the structure and content of education, its accessibility and applicability have undergone profound changes over the years. In order to evolve the most appropriate science education system at the school level for the emerging era, it may be useful to review the briefly the changes through which education system has so far undergone, as also the contours and relief of the emerging scenario.

In India, it is not uncommon to find in our schools and colleges, a student from a remote village sitting by the side of a student from a metropolis, a student who is a first generation learner sharing a seat with a student who has had ten generations of schooling history, a student who can not afford two square meals a day learning along side a student whose pocket money exceeds the monthly budget of the school and yet they are both subjected to the same syllabus, the same pace of learning, the same evaluation of system etc. This rigidity and the so called uniformity has played havoc with the system and has been responsible for almost total degradation of the system.

With the introduction of such a system emphasis shifted from learning to teaching. With the exponential growth in knowledge, particularly connected with science and technology, there grew a tendency to ram into the brains of children more and more in less and less time. With this not only the gravitational load in the form of books and notebooks increased but it also created an unbearable load of non-comprehension. The gravitational load is heavy and some times backbreaking but the load of non-comprehension becomes almost crushing. Some students can compromise with the situation and can go ahead, whereas a larger number and the more sensitive ones amongst them cannot compromise with non-comprehension and they finally give up. This has resulted in a new phenomena of dropouts and fallouts peculiar to India. Today in India, at every step of education the fallouts and the dropouts constitute nearly 50% of the enrolment. This is a colossal loss to the individual student, his parents, to the society and to the nation.

It is hardly realized that today, India is brimming with young boys and girls full of enthusiasm and vitality. They are our most precious national resource. It is their inherent right to have an education system which will enable them to flower to the limits of their capabilities and it is our moral obligation to provide them with such a system. In this connection it may be stressed that the emerging global scenario in which competitive advantage of a nation will be determined by its scientific capability and technological competence will pose daunting challenges and at the same time throw open immense opportunities for our young boys and girls to seize.

It may equally be pertinent to draw attention to the unique historical opportunity that is likely to appear for our young boys and girls to seize and bring glory to themselves and to the nation. Population of India is even now growing, although, the birth rate has come down. We have already crossed 1 billion mark. In contrast, population of advanced countries of Europe, Japan and even to some extent United States has either stabilized or decreasing in some cases. If this change in population of various countries continues at the present rate then in 2030-2040, 45% of Indians will be below 25 years in age. In contrast, 60-65% of people in the above mentioned developed countries would have crossed 65 years in age. In other words, at that time, India will be young, whereas these countries would have aged. In such a unique situation, all these countries will be looking for young bright boys and girls who are highly skilled and highly motivated. We, in India, can seize this unique opportunity provided we start today to prepare and equip our young boys and girls to seize tremendous opportunities this emerging scenario is likely to offer.

**WHAT IS EXPLORATORY?**

Exploratory is a unique science center where the visitors including school and college students can play freely and while playing, learn to explore and discover, invent and innovate, design and fabricate.

Exploratory is so designed that school and college students, while carrying out various well designed activities learn basic concepts in various disciplines, are provoked to develop various applications of basic concepts and are exposed to how basic concepts they discover underlie various industrial products and processes.

Exploratory introduces students to the way great men of science questioned Nature through various experiments to reveal her secrets. Exploratory trains students to observe keenly and carefully, excites their curiosity, communicates a sense of excitement in doing science, nurtures and nourishes their creativity and innovativeness and makes learning a joyous process.

Exploratory helps students to learn how to learn, learn how to do and learn how to live.

**WHY EXPLORATORY?**

Over the last two centuries, science has come to occupy center stage in the thinking and living of man. Science is increasingly shaping our view of the universe, moulding our sojourn on this plant and patterning our ultimate destiny.

One of the most obvious characteristic of science and technology, apart from its objectivity, is the fact that it is growing exponentially with a doubling period of 10-13 years. This exponential growth in science and technology has been responsible in the continual reduction in the time of obsolescence which is now around 3-5 years. This calls for not only one time learning society but a continually learning society and more importantly learning how to learn.

Along with the shrinking of the time of obsolescence, technology is becoming more and more science based along with a continual decline in the time lag between a major scientific discovery and its technological exploitation for economic growth. This makes it necessary for us to be at the frontiers of science so as to be at the cutting edge of technology.

It is essentially the exponential growth in science and in particular in technology with which Soviet Union could not cope that the Soviet Union got dismantled. Berlin wall came down, cold war ended. With this, not only the world became unipolar but a new economic world order has emerged. In the emerging scenario, international relations will be determined more by nation's scientific capability and technological prowess rather than by its military might. Arms race has already yielded place to technological olympiads. In the emerging scenario, intellectual property will assume primacy and intellectual property rights will be fiercely exploited and zealously guarded.

There has been a truly remarkable and dramatic paradigm shift. We are heading towards knowledge societies, knowledge based industries, knowledge based agriculture and so on.

In such a situation, for men and women of the 21$^{st}$ century to be ignorant about science and technology is to be ignorant about science and technology is to be ignorant of a large part of life. It is almost going through life without one of our senses. Many eminent men and academic bodies have expressed concern about the lack of public understanding of science and view this lack of understanding as a great danger to both man's existence on this planet as well as to science itself. More than ever before common men and women need to be introduced to the culture of science and to the objectivity of science.

In addition, the emerging situation calls for almost revolutionary changes in the system of science education so as to enable students to learn how to learn, learn how to do and learn how to live.

The present system of science education in our schools and colleges doles out uncorrelated information about science to be learnt by heart for vomiting in examination. Science is an endless quest and unceasing exploration of nature and natural laws. Whereas technology is the application of this understanding to make human life healthy, happy etc. This nature of science and technology must get reflected in the teaching of science.

However, in the present system, exploration and experimentation have become extinct. Students learn science either from the blackboard or from books and not by participating in science or by doing science. Curiosity of children which is normally inborn, is dampened at every moment. Einstein once said "Curiosity is like a tender plant and it dies even if slightest stress is given to it". In our schools and colleges, mortal blows are given now and then to this tender plant of curiosity. In much the same way, students are dissuaded from asking questions and they have to learn science as if coming from Vedas or scriptures. We forget that asking a question is the first and the most important step in the process of acquisition of knowledge. We must realize that when a student asks a question, he not only expresses his ignorance but more importantly expresses his desire to know the answer. If we dissuade our children from asking even trivial questions, why and when will they ever ask a basic question whose answer may lead to the expansion of human knowledge. It must be realized that at the root of every major discovery in science there was someone who asked a fundamental question.

In the present system of education, there is no place for creativity and innovativeness, no scope to do things with hands. Similarly, the relationship between what children learn and its application to industry is never brought out, with the result, learning science instead of being a joyous experience becomes an unavoidable load.

The consequence of all this is clear and visible. Our students emerge from schools and colleges devoid of curiosity, lacking excitement, not logical and rational, devoid of creativity and innovativeness, lacking self confidence and frightful of their future.

This must change and change early and this is precisely why Exploratory was set up and why the Exploratory way of learning science has been developed. Exploratory intends to make common men and women science and technology friendly and to make school and college students curious, excited, innovative and creative, self confident, ready to contribute to this great kingdom of objectivity namely science and to the powerful instrument of development namely technology.

## PHILOSOPHY OF EXPLORATORY

Exploratory is neither a school or a college laboratory, nor a museum but is a place where visitors can experiment and explore, discover and innovate, design and fabricate.

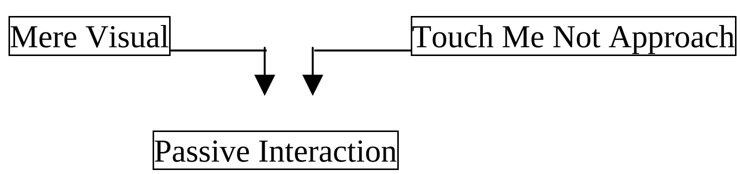
Museums are often looked upon as places for the study of the past and possibly for the projection into the future. In India, museum is popularly called 'Ajaib Ghar' a place of wonder or magic. People are enthralled to see in the museum such natural objects, products or artifacts, which they do not see in the day to day life and are unusual and uncommon either in appearance or in concept or in content. From the study of the past, one looks with amazement at the huge steam engine with chain drive, an equipment used by Edison to transmit messages and so on. For projection into the future, the curator has to be much more imaginative. The latest advancements in science and technology are displayed with a vision, be it in the area of space exploration genetic engineering etc.

Since the Crystal Palace exhibition of 1851 in London, science museums have come a long way from repository of artifacts to wonderland of science. This traditional concept of science museum must change to the concept of science centers-exploratories, by shifting its emphasis from historic artifacts to exhibits with which visitors can play and learn the basic concepts of science, are introduced to the process of science are provoked to design applications based on these basic concepts.

Exploratories should be so designed so as to encourage visitors to ask and answer questions-how, what and why of science through carefully designed exhibits ensuring visitors participation. ‘Touch Me Not’ exhibits fondly preserved in glass cases should be replaced by specially created activities which will bring out scientific principles and to develop applications, to project multiple solutions to a problem. Understanding of science through personal involvement and enjoyment should become the key criteria for an activity to be included in the Exploratory. Exploratory is a place where visitors are helped to explore basic concepts and scientific principles and facilitate them to design new applications based on these concepts and see how these basic scientific principles are at the root of some major technological advancement.

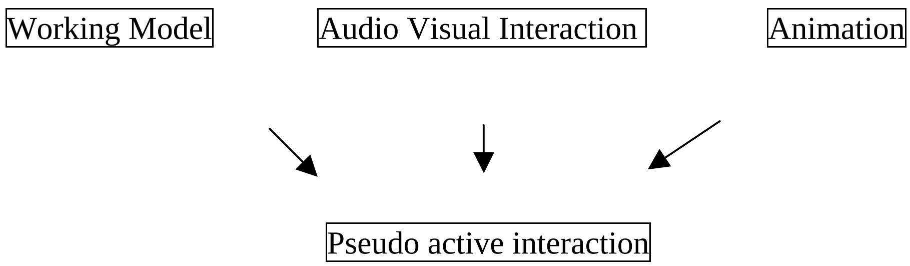
The stages through which this concept of Exploratory has been developed is shown in the following:

Stage I



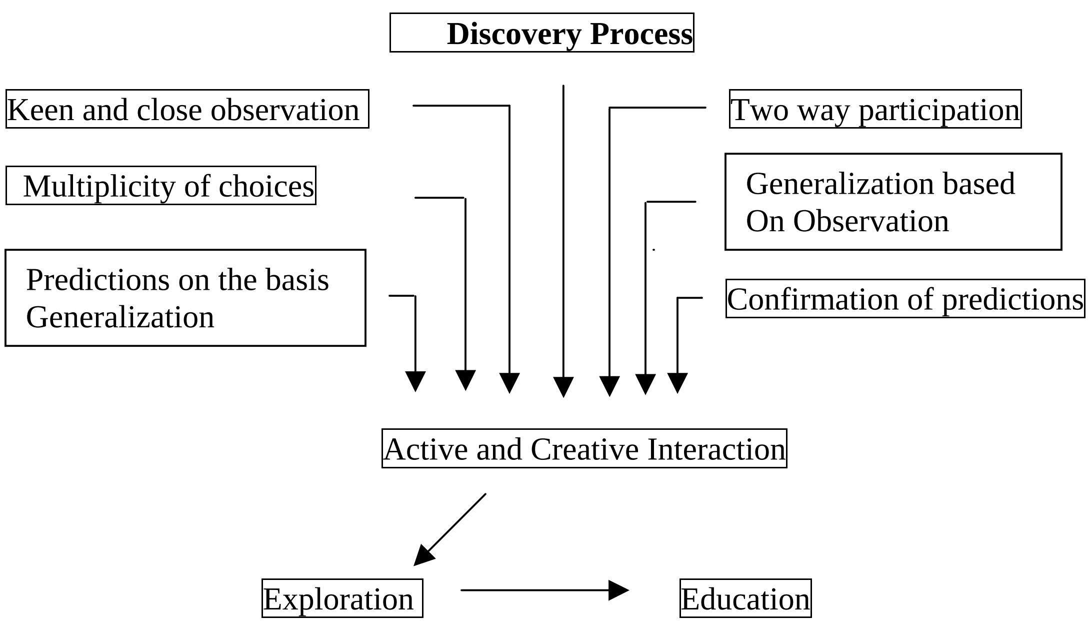

Passive interaction gave way to pseudoactive interation.

Stage II




In the Exploratory, pseudo active interaction is sough to be replaced by active and creative interaction:

Stage III   Active and Creative Interaction:




**FUNCTIONING OF EXPLORATORY**

Exploratory provides facilities to children to explore physical and chemical phenomena, biological processes and to play with numbers, study geometrical patterns, and to design and fabricate electronic gadjets. One of the unique features of the exploratory is the mathematical laboratory in which children learn for themselves mathematical tools and techniques.

Exploratory science center will eventually function in three phases. In the first phase, visitors and school and college students desirous of understanding science will undergo various activities, will explore and discover for themselves some of the basic concepts in physics, chemistry, mathematics, biology etc. This category of activities are divided into five sections.

(2) Physics (2) Chemistry (3) Mathematics (4) Life Sciences and (5) Electronics and Computers.

In the second phase, children will be demonstrated some of the applications of the basic concepts they learnt and will be provoked to design new applications. All facilities will be provided to the children to fabricate their designs, improve on them etc.

In the third phase, children will be exposed to a number of industrial products and processes, with relevant models, charts, cutouts etc. to show how these products and processes operate on the basis on the basic concepts they have already explored and learnt.

Exploratory science centre functions six days a week and forty six weeks a year. Presently, nearly 300 children from various schools enjoy playing in the exploratory and experience exploratory way of learning science.

There are no sylabii in the exploratory, neither is there any fixed sequence or way of enjoying exploratory. There are no teachers in the exploratory. However, there are highly experienced guides, who participate along with children in the process of exploration.

Some typical activities to facilitate Exploratory was of learning science will be described in the following article.

## OTHER ACTIVITIES OF EXPLORATORY

Besides the day to day operation and functioning of the Exploratory, it undertakes several activities which are conducive to the furtherance of the aims and objects of the Exploratory, such as (1) nurturing and nourishing talent at the school level, (2) promoting excellence amongst selected students at the college level, (3) publication of highly illustrative and highly educative books by eminent men of science, (4) development of computer aided science education.

### (I) Nurture and Nourishing Talent At The School Level:

In India, there is a need not only to ensure equity but also a dire need to deliberately and consciously promote peaks of excellence. This calls for nourishing and nurturing talent at all levels. In India, there have been several attempts to identify talent but hardly any efforts to nourish and nurture such talent. Exploratory, right from inception, decided to do so.

Every year, Exploratory conducts talent search at class VII and IX levels in a large number of schools in Pune. This is done by holding a carefully designed examination. Nearly thousand students take this examination. Out of these, forty students are identified both from Marathis and English media, on the basis of their performance at the written test.

Exciting summer programme is organized for the benefit of these students. This programme includes interaction with eminent men of science, playing in the Exploratory, visiting research laboratories and doing a project.

### (II) Nurturing And Nourishing Talent At The College Level:

Exploratory has also a programme to nourish talent at the college level. Exploratory conducts a talent search examination in various colleges in Pune. Some forty fifty students are selected on the basis of this written test. Each one of these students interacts with half a dozen scientists so that his/her aptitude and motivation to do advanced studies is assessed. Based on such an interaction nearly 10-12 students are finally selected.

Each of the students thus identified is put under the guardianship of an eminent scientist in Pune and made a part of a research project in prestigious institutions. These students are enabled to work in research laboratories on a research project while they are still studying at the undergraduate level. With placing these students in the creative atmosphere, it is hoped that they will also creative. In addition, specialized lectures are organised for the benefit of these students.

### (III) Publication Of Highly Informative And Well Illustrated books:

Besides text books which are written in a dull and drab way, students are hardly exposed to any informative, well illustrated literature on various topics in science. To fill this lacunae and to make available exciting, highly informative and well illustrated books to school and college students, Exploratory launched on an ambitions publication drive to publish highly informative, beautifully illustrated and artistically printed books for the benefit of school and college students. These books are written by eminent scientists in popular language. Last year, Exploratory brought out following book in Marathi and English (1) Life History of stars (2) Motion and gravity (3) Black holes (4) Carbon, the wonder element (5) Dolly, the clone (6) Bees (7) C.T.Scan.

### (iv) Developing Computer Aided Science Education:

Exploratory, realizing the great benefit that one can derive in using modern information technology for education, has initiated a programme of developing computer packages for self learning and self evaluation. These self educative, self evaluating and highly interative packages are being developed. Simultaneously, Exploratory has acquired highly exciting and educative TV films. It is intended to exhibit these films once a week for the benefit of school and college students.

**IMPACT OF EXPLORATORY**:

Response of children, teachers, parents and general public to Exploratory and Exploratory way of learning science has been both spontaneous and overwhelming. The performance of students who have experienced exploratory way of learning science has been outstanding both in public examinations such as S.S.C and H.S.C. and in a variety of nationally and internationally held competitive examinations. Two of the students who had experienced Exploratory way of learning science represented India at the International Mathematics Olympiad in 1997 and 1998 and won a bronze and silver medal and a gold medal respectively. Last year, one of our students Shri Dylis Thomas represented India at the Helsinki and received commendation from the President. In addition, two of our students won International awards. Exploratory has made a visible impact on the educational scene in Pune and is lauded by the general public and scientific community in the country.

Exploratory is a unique and novel institution, one of its kind in the country. Looking at its success, several requests have been received to establish such exploratories at their respective places.

**NCERT: AN APEX RESOURCE ORGANISATION**
**IN SCHOOL EDUCATION IN INDIA**

***R.D. Shukla***
(NCERT, Sri Aurobindo Marg, New Delhi 110012, India)

The National Council of Educational Research and Training (NCERT) is an apex Resource Organisation set by the Government of India with Headquarters at New Delhi to assist and advise the Central and State Governments/Union Territories on academic matters related to school education. This Organisation undertakes research development, training and extension programmes to fulfil its commitment towards school education. In this venture, NCERT faces many challenges at National Level. It tries to

- bring educational reforms at national level catering to the needs of a large number of institutions/schools of different stages with different educational needs.
- deal with emergence of new educational concerns and imperatives like value orientation of school education influence of information and communication technology.
- bring curriculum reforms and capacity building
- work for achieving universalization of Elementary Education
- meet the challenges of rich and poor, works for gender equality, equality of learning with special needs and of disadvantaged groups of society at national level.

Selected educational statistics during 1999-2000 is given in the following boxes reveal the number of schools, enrollment of students and the number of teachers in India.

| Schools | |
|---|---|
| Primary Schools | 0.642 million |
| Upper Primary | 0.198 million |
| High Schools | 82.30 thousand |
| Higher Secondary Schools | 30.1 thousand |

| Enrolment of Schools | |
|---|---|
| At Primary level | 82.39 million |
| Upper Primary level | 49.32 million |
| High School level | 28.72 million |
| Higher Secondary | 25.6 million |

| Stages | Teachers |
|---|---|
| Primary | 1.919 million |
| Upper Primary | 1.298 million |
| Secondary | 0.97 million |
| Higher Secondary | 0.75 million |
| Total students | |

ENROLMENT OF STUDENTS AT HIGHER SECONDARY STAGE

| | BOYS | GIRLS | TOTAL |
|---|---|---|---|
| Total Enrolment of students (data base 1993) | 350,194 | 1,963,360 | 5,465,154 |
| Enrolment of students in Science (data base on 1993 Survey) | 1,046,214 | 466,550 | 1,512,765 |
| Estimated number of students in Science (1999-2000 base) | 1,792,195 | 874,207 | 2,666,402 |

| Number of Teachers teaching Science | | | |
|---|---|---|---|
| | Male | Female | Total |
| Secondary Stage | 206,282 | 79,496 | 285,784 |
| Higher Secondary Stage | 477,706 | 15,445 | 63,151 |

The activities of NCERT in school education includes the following:

- development of curriculum
- development of Syllabi and Textbooks
- development of instructional materials/supplementary materials
- promotion of laboratory skills/practical activities
- popularization of science education
- organization of out of school activities/exhibitions at the District, state and national levels.
- club activities and
- promotion of talents in science education
- responsibility of providing a forum for students and teachers in the form of a Journal "School Science" for disseminating scientific innovations and sharing experiences
- development of kits, models and multi-media for promotion of science education.

NCERT has brought out textbooks with different approaches during the period 1965-2002 at the various levels of schooling. These are given in the box.

| | |
|---|---|
| Primary Stage | Environmental Approach -<br>Environment as a laboratory |
| Upper Primary Stage | Disciplinary Approach |
| | Integrated Approach |
| | Science and Technology Approach |
| Secondary Stage | Disciplinary Approach<br>Integrated Approach<br>Combined Science Approach<br>Physical Sciences and Biological sciences Approach<br>Science and Technology Approach |
| Higher Secondary Stage | Disciplinary Approach with emphasis on concept development<br>Disciplinary Approach with emphasis on application of technology and contemporary knowledge in the concerned discipline |

NCERT recognized that an integral part of science education is the laboratory oriented programmes.  Towards this, it has brought out

- Development of kits and kit manuals for primary and upper primary stages of school education
- Pupil’ kits
- Laboratory Manuals
- Laboratory Worksheets
- Investigatory Projects
- Concept based experiments

  (i) for demonstration of teachers

  (ii) to be performed by students as a group activity.
- Development of 3-Dimensional models

***Audio-Visual materials for promotion of science education:***

NCERT developed audio-visual and CD for promotion of science education. These cassettes are available for sale at the Sale Counter of CIET.  Some of the cassettes are used  for developing ***Scientific and technological literacy*** among the students and masses.  A full-fledged Institute known as Central  Institute of Education Technology (CIET) has been established under NCERT.  NCERT also broadcasts its programmes/lessons on Doordarshan and All India Radio in the area of  Science. NCERT has developed by this time nearly 1500 video and 2000 audio programme.

***Popularization of Science among students and masses***:

- Development of Supplementary  materials/books in frontiers of science under the project, ‘Reading to Learn’ by associating eminent scientists/technologists/mathematicians of the country.  The Project covers basic science area, computer science, space science and cosmos, biotechnology, marine science and oceanography, medical sciences, nuclear  sciences, energy, weather and environmental sciences, health sciences and nutrition, mathematics, material science etc.

- **Science Club Activities**

  Investigatory projects at relevant stages of school education

- **Science Exhibitions**

  District, State and National level Science Exhibitions

  These exhibitions are organized on various themes and sub-themes in area of science and technology. These exhibitions promote creative activities of students and nurture their talent. These exhibitions also help in disseminating application of science and technology for the society.

- ‘School Science’ Journal and other materials to make teachers and students conversant with various new areas of science and contemporary changes in various fields of science.

NCERT is, perhaps, one of the earliest organization to initiate a programme for early identification of talented children in schools and nurturing them through out their career to enable them to become good and responsible scientist in the country. NCERT initiated National Science Talent search Scheme nearly 35 years back, which was converted into National Talent Search after 1975. Under this Scheme, every year 750 students got scholarships in all areas of their studies up to Ph.D. level. NCERT also organizes Nurturance Programmes in summer in collaboration with Universities/Research Institutes. Only recently, NCERT submitted a proposal to Planning Commission through Ministry of Human Resource Development (MHRD) for initiating a fresh scheme for National Science Talent Search. Under this Scheme, only those students will be eligible for the scholarships who pursue their career in basic sciences. The Scheme will be valid upto postgraduate level only.

Despite all these measures, there has been a fall in the enrolment of students for science based courses. A few possible reasons are given in the box.

Career Prospects

Lack of interest/motivation

Science is more demanding than other disciplines

Inherent weaknesses in teaching learning process

Curriculum Load and Teacher preparation

Evaluation in Science

The vast experience gained in the school education permit us to list a few measures for improving quality and promoting excellence in science education. These are:

- There should be emphasis on experimentation in teaching learning of science. More emphasis should be laid for processes of science rather than product of science.

- Science practicals should be an integral part of every evaluation/assessment in the entrance examination so that practicals are not neglected in schools, as is the present scenario.

- 26% schools in the country do not have adequate facilities for science laboratories. Necessary infrastructural facilities including laboratories should be provided for improving the quality of science education.

- Science should be taught the way scientists practise it in their laboratories. For promoting excellence in science education students should be provided investigatory project work.

- A comprehensive action plan should be worked out for capacity building. Teachers should be trained in content and methodology. A joint effort is needed and for this task by different ministries, research organizations, INSA. All these organizations should join hands with NCERT in this national task. Necessary efforts should be made for promoting excellence in science education as being done presently by a few organizations, NTS undertaken by NCERT, KVPY by IISc, Bangalore and DST, CSIR on the basis of boards percentage of marks in the examination.

# SCHOOL SCIENCE AND MATHEMATICS EDUCATION IN INDIA: SOME MAJOR CONCERNS AND SOME INTIATIVES

***Arvind Kumar***

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Equity, excellence and relevance are the three major concerns of school education in India. Language barriers, both natural and artificial (even in vernacular medium schools), socio-cultural and gender stereotypes, and the cascading effect of poor learning at the primary stage, particularly of mathematics, are some of the key factors hampering universalization of science and mathematics education in India. There is, of course, the main disabling factor-inadequate national investment in education. The impediments to quality are well-known; a dominating examination system that stifles the initiative and creativity of even the best teachers and students, inadequate infrastructure (laboratories, libraries, etc.) and lack of preparation and motivation among the teachers.

Despite the grim scenario, there are a number of positive features. The democratic frame-work permits multiple viewpoints that has helped maturing of perspectives on science and mathematics curriculum. There is a positive perception of science and scientists among students, teachers and general population. A mass of organizational structure of education has been built in the country which, with all its faults and failings, has vastly improved access to education among the underprivileged. Good quality work by several NGOs is contributing to the enormous national task, if only on a limited scale. The recent strengthening of the Olympiad movement in mathematics and basic sciences is an important step towards promoting excellence.

In this talk we describe in some detail the work carried out by *Ekalavya* (an NGO based in Madhya Pradesh) and the *Homi Bhabha Centre for Science Education* (a

National Institution devoted to R & D and training work in school science and mathematics).

**Some Initiatives in Sc. & Maths. Education**

(*Illustrative, not exhaustive, nor even representative*)

**Grassroots progranmmes aimed at equity**

**Ekalavya (1982 - )**

Madhya Pradesh (Headquarters: Bhopal, several field centers)

***Objectives***:
To introduce a new vision of education, to bring qualitative changes in the formal school system; to make quality education accessible to the deprived sections, to build scientific temper of children and teachers.

***Programmes***:

| | |
|---|---|
| Hoshangabad Science Teaching Programme | 1000 middle schools |
| Social Science Teaching Programme | Smaller scale |
| Primary School Education Programme | Smaller scale |

***Key inputs***:

- Regular teacher orientation
- Building a high quality resource team of teacher trainers
- Innovative curricular materials and resource materials for teachers
- Popularisation of science (bal melas, mobile libraries, child activity centers, etc)

***Materials (in Hindi)***

| | |
|---|---|
| *Bal Vaigyanik* | Middle School |

| | |
|---|---|
| *Khushi Khusi me* | Primary School |
| *Chakmak* | Children's magazine for popularization of science |
| Hoshangabad Vigyan Patrika | Project Magazine resource |
| Sandarbh | Resource magazine for teachers |
| Strot | |

Low cost experiments, teaching aids, etc.

***Paradigms*:**

- Empowerment through participation, discussion, questioning etc
- Integrated curriculum (science, social science, language) at the primary level; integrative perspective at all levels
- Non-formal, local specific; curricular transaction (books and classroom discourse)in simple, live language
- Addressing issues of environment, pollution, health, education, women and other societal issues.

**Homi Bhabha Centre for Science Education (HBCSE), Mumbai**

**(1974 – 1981 - )**

**(National Centre of Tata Institute of Fundamental Research)**

**Areas of Work**

- Science and mathematics education of the socio-economically disadvantaged groups (first generation learners)
- Teacher orientation (National, State level agencies and other networks; NGOs)
- Development of innovative curricular and co-curricular materials
- Science popularization (mobile laboratories, exhibitions, books, radio, TV)
- Promotion of excellence at senior secondary level through Olympiads in mathematics and science

- Research in science and mathematics education

***Perspectives that inform HBCSE's work***

* Cognitive * Affective * Gender * Health & nutrition * Language
* Historical/Developmental * Integrative * Ecological * Technological
* Creative

***Some notable projects of HBCSE for the deprived groups***

- SC project for BMC students (1980-1985)
- Language simplification of textbooks in Marathi
- Multi-tier teacher orientation projects in Maharashtra (Surgana, Dahanu, Ramtek, Solapur)
- Ashram School (Residential schools for tribal students)Project (covering about 140 secondary schools in 9 districts)

***HBCSE's remedial programmes focus on***

- Active learning of science (experiments, problems, questions)
- Specific cognitive strategies
- Language development (language enrichment not only for but also through science)
- Boosting students' self-image

***Results***

- Pilot scale programmes involving direct contact with students effect dramatic improvement in performance

- Large scale programmes – effect very diluted but positive; retentivity is low or negligible if effort is not sustained

## Materials

**Homi Bhabha Curriculum (Primary science and mathematics)**

- Aims at engaging students and teachers in a joyful and meaningful learning experience
- Abounds in simple but insightful activities
- Evolves continuously through field testing
- Language development, design, drawing and measurement skills are especially emphasized
- Gender fair
- Implicit value education

**Foundation curriculum (at secondary/senior secondary level)**

- Issue-based interdisciplinary curriculum woven around issues of human survival: Population; Energy: Land & Air; Education; Global change: Ecological Balance; Conflicts; Health

***Popular science materials***

- Books for children and general readers
- Slides/posters
- Comprehensive exhibitions on
    - History of Science
    - Science for sustainable living
    - Gender and Science

- Portable laboratory in science and mathematics for children
  (About 100 illustrative experiments/activities emphasizing the principles of science at school level)

## Promotion of excellence at secondary/senior secondary stage

***Olympiad Programme in India***

- Maths Olympiad Programme initiated by NBHM. India started participating in IMO from 1989. Training camps for National medallists at HBCSE since 1996.
- Olympiad Programme in physics. Jointly launched by HBCSE and IAPT. Extended by HBCSE to chemistry and biology. India started participating in IphO (from 1998), in IchO (from 1999) and in IBO (from 2001)
- Astronomy Olympiad programme being carried out by ASI, NSC, IUCAA
- Informatics Olympiad from 2002 (BASE and other agencies)
- Other similar activities (Robotics, Intel Science discovery Fairs, etc.)

***Indian performance at the International Olympiads (in mathematics & sciences)***

- In the last five years, everyone of the 19 students sent by India has returned with a medal/honour.
- Special prizes for best solutions, etc. right in the initial years of participation in physics.
- Outstanding performance in physics in 2001. (Next only to China and on par with Russia and USA in terms of medals).
- India hosted the 33$^{rd}$ International Chemistry Olympiad in July 2001 in the third year of participation.
- In 2002, an Indian student topped the experimental contest of the 34$^{th}$ International Chemistry Olympiad, Groningen, The Netherlands.
- Over-all, as a rough indicator, India is among the top 10 countries of the world in all the four subjects, but not among the very best three or so.

*Fallout of the Olympiad movement*

- Tremendous interest among the meritorious students for excelling at the Olympiads
- Generation and expansion of resource base (college teachers) for handling Olympiad level problems and experiments,
- Keen interest among several scientists to contribute to the programme. Olympiad are an excellent context for scientist – teacher linkages in the country.
- Junior Olympiads
- Formation of academic teacher associations (IACT)

However, the Olympiad movement in India has several organizational and other lacunae, and need upgradation of selection and training procedures in many ways.

## Research in Science and Mathematics Education

Rapidly expanding field at the global level. In India, small but growing:

Cognitive and Pedagogic studies

- Alternative frame-works in specific topics of science
- Knowledge frame-works of young children (urban, tribal etc)
- History and cognition
- Procedural and conceptual understanding in mathematics
- Number learning and operations
- Errors in mathematics

### Attitudinal studies

- Perception of science and scientists (among students and teachers)
- Gender stereotypes/bias

- Career aspirations among the deprived

## Some other notable Non-Govt/Semi-Govt./Govt. agencies involved in science popularization and science education

- All India People’s Science Network
- Bharat Gyan Vigyan Samiti → Meeting Ground for Peoples’ Science Movement and National Literacy Mission
- Kerala Shastra Sahitya Parishad (KSSP)
- Tamil Nadu Science Forum
- Andhra Pradesh Science Forum
- Marathi Vidnyan Parishad
- Delhi Science forum
- NSCM, Vikram Sarabhai Centre, CEE
- IWSA, CSE
- Lok Jumbish
- Vigyan Ashram (Pabal)
- Exploratory (Pune)

# TRENDS AND CHALLENGES FOR SCIENCE EDUCATION IN KENYA

***Joseph O. Malo***
(Physics Department, University of Nairobi, Nairobi)

## 1.1 **Introduction**:

The problem Africa is facing today is under-development that manifests itself in terms of poverty, diseases, ignorance and many other forms. It is regrettable to recognize and note that due to the severe but an apparent lack of funds and other resources, many African countries have remained impoverished over the years. The weak fiscal status and the dim prospects for drastic economic improvement coupled with mismanagement, corrupt and despotic regimes in the continent also militate against any significant local support to alleviate the problems of under-development in the near future. From the experience of the industrialized countries, it is abundantly clear that for Africa to develop and survive this century, science and technology must take root in the continent to serve the people and improve their standards of living by increasing productivity. It is also well understood and recognized that for science and technology to benefit the continent, human resources development i.e., capacity building in general is paramount and basic. There are a number of prerequisites for capacity building and this involve issues and questions which must be addressed and put in place.

Such prerequisites include inter alia (a) schools, colleges, universities, polytechnics, research centers and institutes for both biological and physical sciences for teaching, training and to address specific and interdisciplinary mission oriented development problems (b) forums such as societies, associations and academies to provide opportunities for exchange, debate, imparting knowledge in terms of seminars, training workshops, scientific conferences and also to promote utilization and popularization of science and technology by organization of science fares and congresses (c) Physical facilities and equipment (d) highly trained technicians including repair and maintenance (e) an enabling environment.

1.2 **Science and Technology**:

It is today generally accepted that technology is " the engine of economic growth" and technological innovation is indeed the principal currency of international competition. Thus technology plays a key role in attaining major goals in invigorating countries competitiveness in the global market place.

A science and technology policy should therefore aim at improving the effectiveness of a national system of innovation, supporting public research and education, and sustaining the competitiveness of the business sector. So a major policy area should therefore focus on the promotion of innovation and investment, the diffusion of advanced technologies and creation of new firms. Thus a mechanism must be put in place for funding technological innovation by providing grants, low interest loans and risk capital for supporting individuals and cooperative research projects including downstream innovation projects in sectors such as electronics and material science.

African decision makers have failed to link science and Technology with development objective such as enhancing quality of life of citizens. Thus lack of nations' commitment to systematically translate such policy into operational program that will certainly transform the society is most unfortunate. In general, there is an absence of realistic or implementable Science and Technology policy that can be used as an instrument to effect Social changes, coupled to no government commitment to inculcate Science and Technology culture in the youth and populate beyond what is available in the formal setting of classroom and research laboratories. It is therefore not surprising that sub-saharan Africa has a new name "Technology Desert" in today's space age where Information and digital Technology have reduced the world into a Global village.

In many African countries, there is a crisis in Science Education leave alone Research. Motivation to study Science at school is often very low especially among girls. Thus there is a need to predispose very young children especially girls to Science through the provision of practical experiences that involves the use of appropriate toys and games. It is vital to note here that the trend towards the economic "globalization" carries the technological innovation to directions which are not always compatible with Culture, Social behavior and Environmental conditions of different countries. For example, the European model differs from the American one since different attention is paid to problems of the environmental values, preservation and to the compatibility of the "NEW" with cultural and social history of each country. Further the lack of industrial base to absorb science graduates i.e. job opportunity, apart from being a school teacher, has a negative contribution in the career decision making process right back at school level.

Africa and its people must accept the fact that Science and Technology drives the economic world-order and thus all visions of development emanate from the promotion of Technology. Thus recognition of the power of Science and Technology as the economic engine of a nation has persuaded countries in Latin America and Asia including industrialized countries to give priority to the establishment of infrastructures such as planetarium, science museums and parks as mechanisms for nurturing of a science culture particularly among the youth and for educating the public in general and even declare year of Science and Technology. These structures would act as business incubators and local centers for spreading the use and acquisition of technology.

## II **CHALLENGES:**

### II.1 Attitude to Sciences:

Research conducted in Kenya, by the Schools Inspectorate and the Kenya Science Teachers College, revealed that a negative attitude towards Science subjects by schools and indeed students is a major contributor to poor examination performance. Secondly the large expenses needed for establishing laboratories also discourage many schools from offering these subjects. Most schools view the subject as special and difficult that such subjects are can only be taken by a few bright or gifted students. In Kenya, Mathematics is compulsory but still suffer poor attendance. Some of the grim statistics are:

1. 39,254 (21%) out of a total of 178,608 candidates who sat for the Kenya Certificate of Secondary Education (KCSE) in the year 2000 took physics.
2. Enrolment for Biology and Chemistry stood at 59% and 63% respectively.
3. More boys than girls enrolled for Chemistry and Physics examinations with only 13% of girls taking Physics.
4. In Biology the ratio between boys and girls was even.
5. In one district (Malindi) no girl took Physics in KCSE in the year 2001 while only 55 out of 360 boys were examined in Physics.
6. The situation was even worse in Isiolo District's Garbatola High School, the only institution in northern Kenya, where none of the candidates took Physics. However the schools offer Biology and Chemistry but it was closed in the year 2000 due to very poor state of the buildings;
7. (a) In the rest of Isiolo only 2 out of 134 girls took Physics

   (b) In Meru North and Wajir districts no boy or girl took Physics

   (c) In North Eastern Province 17 students, all boys, took Physics.

The above statistics were reported at a recent Head Teachers Association Conference in June 2001 and the Heads resolved to help change the trend by giving more emphasis on the sciences and mathematics. They further noted that there was mass failure Physics and Mathematics in the year 2000 with 2% scoring an 'A' grade.

The Japanese International Cooperation Agency (JICA) is sponsoring a Pilot Project in 10 Districts to help resolve the problem facing the subjects and is aimed at changing the attitudes of the key stakeholders. JICA is also conducting in-service training for science teachers in some Districts. The Science teachers are invited to attend these courses to upgrade their skills for effective teaching of the subjects.

## III GENDER AGENDA IN SCIENCE

It is generally accepted today that participation of girls in science and technology is indeed a prerequisite for attaining quality education for all and will in turn catalyze socioeconomic growth. It is unfortunate that given the above scenario, practical strategies are hard to come by to enable teachers achieve this goal.

A recent publication of the Commonwealth Secretariat reports that a new study requires a paradigm shift that teachers be made aware that girls and boys learn science and technology differently. Girls also work more cooperatively and they are attracted to science since they see it as socially relevant. The long and short of this is that teachers need to be sensitized to factor in these when teaching science. Similarly curriculum developers must design the content in a way that captures the imagination of girls and boys in order to sustain their interest. In other words teaching science and technical subjects in an abstract manner excludes many learners especially girls. The general effect of this is the creation of a tiny group of learners pursuing sciences which is detrimental to the academic and economic growth of a country. There is need to adopt practical approaches to interest learners to science. Some countries have come up with ingenious ways of addressing problems which can be replicate elsewhere.

(1) **Ghana**:

They started a programme dubbed "Science, Technology and Mathematics Eduation (STMES). A clinic was established back in 1987 which encourages gifs to take Science and Mathematics subjects, perform them well and continue studying them. The clinics routinely bring together girls from different schools for intensive exposure to science environment, where they interact with Female Scientists and visit key science institutions. They also go for field visits where they see how scientific concepts are translated into practical projects for human benefits.

The clinics also offer in-service training to Science and Technology teachers to be able to adopt gender-sensitive pedagogical approaches. They learn how to involve girls in creative and hands-on activities that make Science and Technology relevant to their lives. Thus records indicate that within five years of its inception, the project had increased girls participation in Sciences at the secondary school by 76%.

(2) **Botswana**:

A programame called "Road Show" has been developed whereby Female Scientists and Technologists visit schools to talk to girls and give them practical skills on teaching Science and Mathematics in a way that is accessible to both sexes. By and large the commonwealth secretariat underscores the fact that Science and Technology must be gender responsive. Infrastructure including laboratories and equipment must be accessible to both boys and girls. For some reasons, more boys and girls schools are well endowed with learning resources and facilities giving undue advantage to one lot as compared to the other. Teaching materials must be gender-sensitive and at the same time, women science teachers need to be recognized as mentors and role models for girls. Lastly, science teaching should also be broadened to include elements of economics, social and ethical dimensions.

## IV TEACHER TRAINING

Recently in Kenya, a committee was set up by the Ministry of Education after receiving proposals from Principals of Teacher Training Colleges who made a number of recommendations. Among them was that Certificate and Diploma teacher trainees will require higher qualification to join Teacher Training Institutions if the new proposals is accepted by the Ministry of Education and indeed the Cabinet. Those seeking admission to Languages and Sciences and at least a $D^+$ in Mathematics. The minimum requirement for pre-school teacher training courses will be a mean grade of $D^+$. The proposals are aimed at reforming teacher education and ultimately ensuring quality science teaching in schools. In their proposal to the Ministry of Education contained in a document "Challenges in Improving Teacher Education in Kenya", the Kenya Teachers Colleges Principals agreed for higher entry requirement for trainees since without quality teacher training we cannot have quality education, neither can we have quality labour force.

It was instructive to reveal that Curriculum for Teacher Training has never been revised since independence. Further recommendations were: students seeking to enter Diploma colleges will require a minimum of $C^+$ up from C at the KCSE and will also require a C grade in English and Mathematics. The emphasis on English and Mathematics is due to the fact that many teachers especially those in primary schools, lack proper grasp of these two subjects which are vital in all aspects of academic pursuits as well as further training and job placement. Candidates have perennially performed poorly in Mathematics and Sciences at the primary and secondary levels which is attributed to teachers poor grounding in the subjects. Ministry of Education further recommends for the Cabinet's approval, higher budgetary allocations to the institutions to enable them provide facilities and services to ensure proper training.

The report also proposes a regular Appraisal System to review the teachers effectiveness and the strengthening of Teacher Training Colleges (TTC) to become centers for teacher educators. The curriculum be reviewed to allow for specification and incorporation of electives to ease the work load for trainees. Further the new curriculum should include emerging issues of guidance and counseling, multigrade and multishift teaching systems. Information technology would also be adopted in the teacher education curriculum. The bottom line is that, if we are to provide quality education to meet the challenges of the 21$^{st}$ century, we need to address the issues that hamper quality labour force.

It is also instructive to note that a casual analysis of those who get admission shows that TTC receive people who are mainly at the bottom of the academic ladder. Most of those who find their way into teacher training institutions possess $D^+$ and $C^+$ aggregate grades. Statistics further reveal that the majority of them have failed in core subjects like Mathematics, Sciences and English. Another fundamental contradictions in teacher training is that some students training as P1 are more qualified than their colleagues pursuing Diploma courses. Last but not least, inadequate physical facilities like classrooms, laboratories, libraries and workshops cause major constraints especially for old colleges which are designed for a lesser number of trainees.

## V CONSTRAINTS

The reason why performance in Mathematics and Sciences is poor in primary and secondary schools national examinations are deeply rooted in the teaching and learning system. The teachers are poorly trained and students have low morale to learn while the curriculum is broad and overloaded coupled with lack of laboratories and workshop for practical subjects. To improve the quality of teaching, teacher training has to be transformed. As currently constituted, the training is poorly conducted and has a lot of inconsistencies. To train as a teacher all what is needed is some academic grade (low) and such important elements like one's interest in the job, character and conduct are not taken into account. Thus many people join Teacher Training Colleges as a last resort such a better grade in Mathematics, Science and languages does not give a student an edge over others with lower grade. The reason for pushing for upgrading of the entry requirement is that is it unrealistic to expect teachers who did poorly in Mathematics, Sciences, and languages to provide the right skills to their pupils.

Another problem bogging down the teacher training programme is the quota system, where selection is based on zones, divisions and districts. The net result is that areas where students do not have good grades end up sending failures to TTC to meet their quota. This denies performers from other regions a change to train and become good teachers. Thus because of the poor academic background some of the ill-trained teachers are forced to teach in their mother tongue. No wonder some of the University Graduates are poor in English because of poor grounding at their formative stages.

What is needed urgently is a constant curriculum review and in-service courses for Teachers/ Tutors who should show interest and positive attitudes towards Mathematics, Science and Languages. The training should be broad, detailed and specialized. The Sciences and Mathematics knowledge and skills should be imparted in the best way possible. The teacher should be professionally trained in knowledge, content and pedagogical skills. For quality teaching to take root, there is a need for a balance between content and methodology, adequate teaching facilities, professional support and good remuneration package. Last but not least, there should be pride and satisfaction in the teaching profession just as in the case with others, for example, law, engineering, medicine and accounts. The Tutors should be forward-looking and well prepared to mould teachers who can efficiently provide quality education in schools.

A Regional conference was organized by the Association of Development of Education in Africa (ADEA) in conjunction with the Commonwealth Secretariat in Nairobi in August 2001. The conference focused on empowering teachers to improve delivery and enhance quality of education particularly Science. It underscored the need for providing the staff with teaching resources and continuous training. Teachers do indeed require skills to harness the new information and communication technologies (ICT) to improve their knowledge and pedagogical delivery. It is well known that learning efforts cannot succeed unless teachers are well prepared and facilitated to support Science Education. Empowering teachers include provision of inputs such as textbooks, reference materials, subject kits and continuous training.

Many African countries established Teacher Resource Centres (TRC) in the 1960s and 1970s and there is a need for the centers to be re-evaluated and indeed re-focused. They proved very successful in those early years but most of them have degenerated to insignificance due to a number of reasons including low funding and inadequate facilities. A baseline study, that was presented by a consultant Ms. Dawn Quist at the Conference, underpinned the fact that the Resource Centres do require new management structures, proper staffing and effective communication network.

The ravages of the HIV/AIDS scourge and its impact on Science Education cannot be overemphasized. It has thus become necessary to provide teachers with cognitive and effective skills to handle the subject at schools. The heat is felt by both the teachers and pupils according to the Permanent Secretary Kenya's Ministry of Education. He laid down statistics which indicated that 1.3 million children in the country had lost their parents due to Aids. For these children, continued stay in schools is not guaranteed. The psychological impact of losing both parents and the ensuing financial difficulties had acute and negative impact on children effective participation in school. Similarly, teachers mot of whom work in the rural areas, were a high risk lot and their absenteeism because of illness and eventual demise is dealing a severe blow to education in general. Besides, the teachers have to learn to cope with the Aids orphans who require both moral and financial support to continue with studies.

Although a number of African countries have institutionalized Aids lesson in the curriculum, it is clear that this has not led to behavioral change. This may be so because the focus has been on information and awareness creation while little has been done to assist the victims cope with their very grave situation. So education should be concerned not only with preventing the spread of the disease but also mitigating its impact.

The question of teachers poor pay packages is a major constraint and although many African governments are going through economic hardship, it is imperative that the teachers be well renumerated and motivated to perform. Thus if education is priority for national development, then the welfare of teachers must be a priority for the governments. So it is indeed paradoxical when governments slash funding for education because it is a non-productive sector yet it is the basis for socio-economic and political growth. Need to increase funding.

Some of the challenges to teacher management include utilization of information and communication technologies (ICT), working in civil strife-torn regions and among refugees. Last but not least, globalization and emerging economic and trading blocks are also sending signals that the practice of teaching and evaluation must be changed.

## VI **NEW TRENDS**:

The Nyanza Province Secondary Schools Awards Programme was started in 1997 by Friends of Science Education in Nyanza. It gives prizes to the chosen best schools in Biology, Chemistry, Physics and Mathematics. Awards given include trophies, certificates, equipment, consumables, books and indeed prize money to best ten students boys and girls. Both teachers and students have been highly motivated through the award scheme. We have seen performance in the Kenya Certificate of Secondary Education Examination improve greatly for the province. For instance in 1999 Examinations there were 63 boy science students scoring ‘A’ in Biology, Chemistry and Physics. In the same year only 14 girls scored 'B' in the same subjects in the Examinations.

In 2000 the performance was very much improved as shown in the table below:

**Table 1: High Quality passes for Gender**

| GENDER | A | | A - | | B | | B - | |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 |
| **BOYS** | 15 | 10 | 187 | 115 | 585 | 306 | 1078 | 659 |
| **GIRLS** | 3 | 0 | 8 | 13 | 76 | 35 | 234 | 129 |

For the first time, the Province realized three female students compared to fifteen of the boys.

For the first time Nyanza Province was ranked 3rd in Science performance as in Table 2 below and the general trend is that female students have significantly improved in their high quality passes in year 2000 compared to year 1999 as is reflected in the table below.

***Table 2: New System of Schools Ranking***

According to the new system, Nyanza was representing all the four categories as follows.

| SCHOOLS CATEGORY | TOP SCHOOLS NATIONALITY | NYANZA | POSITION |
|---|---|---|---|
| National Schools | 18 | 1 | 13th |
| Provincial Schools | 100 | 24 | 1st |
| District Schools | 100 | 35 | 1st |
| Private Schools | 20 | 1 | 6th |

This phenomenal improvement may be a result of many factors. However, all things being equal, the only difference has been the establishment of the Awards Scheme in the province.

The Kenya National Academy of Sciences has also initiated training of teachers in micro chemistry. Todate over 100 Chemistry teachers have been taught. Over 50 schools in Nyanza and Western Province received microkits donated by and Japan Embassy in Kenya. Our follow up of these schools indicate that most of these are able to do practicals for the first time. The adoption of microscience in schools syllabus has delayed the extensive use of the kits.

## VII GENERATION OF EXPERIMENTAL MATERIALS

### VII.1 BACKGROUND

School Equipment Production Unit, in short SEPU was set up by the Government of Kenya in 1975 in response to the need for the production of Science Equipment and Materials within Kenya. It was set up to run as a Company under seven subscribers as outlined below:

1. PERMANENT SECRETARY - MINISTRY OF EDUCATION
2. PERMANENT SECRETARY - MINISTRY OF FINACNE
3. DIRECTOR - KENYA INSTITUTE OF EDUCATION
4. SECRETARY GENERAL- JOMO KENYATTA FOUNDATION
5. PRINCIPAL COLLEGE - KENYA SCIENCE TEACHERS
6. SECRETARY - KENYA NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY
7. PRINCIPAL COLLEGE - KENYA TECHNICAL TRAINING

Since its inception, SEPU has developed and produced many pieces of apparatus including three Science Kits. It has offered other ranges of laboratory chemicals and apparatus, repair and maintenance of equipment, Installation of Gas Systems and Water Systems and Production of School Benches and Stools in School Laboratories.

### VII.2 GOVERANCE

SEPU has a Board of Directors and Management Team drawn from the above Subscribers. It has a General Manager as the Chief Executive.

- The Director of Education has always been the Chairman of the Board of Directors.
- The General Manager is the one who looks at the day to day running of the Unit.
- Both the General Manager and the Workshop Manager are seconded from Teachers Service Commission.
- The Board of Directors is supposed to hold a meeting at least once a year.

### *VII.3 ACTIVITIES*

SEPU offers the following:

- ➢ Services to Kenya National Examination Council i.e. Manufacturing Practical Examination Materials
- ➢ Manufacturing Institution Furniture and Equipment e.g. Tables, beds, Chairs.
- ➢ Importing some equipment and chemicals and then selling to schools in small batches and other institutions.
- ➢ Designing laboratories and equipment to suit different needs.
- ➢ Exporting SEPU's products to neighbouring countries.

Currently SEPU has 40 members of staff and sales turnover is about Kes. 35 million (approx. US$5 million)

## VII CONCLUSION

Francis Crick, the molecular biologist, in his book ‘Life Itself’ remarks that “To show no interest in what science is achieving today is to be truly uneducated”.

Today in Kenya science learning find itself in an appalling condition, no wonder only a miserable percentage of boys enroll for Physics, Chemistry, Biology and practically no girl. This general uninterest in science is accompanied by lack of money with which to build, equip laboratories, shortage of books and indeed Science teachers.

In Africa, Kenya included, there is deep fear of scientific knowledge and indeed knowledge in general. Our fear of natural science is rather special because science is supposed to be ‘Difficult’ than the Humanities. It is also important to know the historical perspective that older generation grew up with the attitude that ‘the Humanities’ were the only subjects for ‘Gentlemen’. These were inculcated out of need to train Africans as colonial Mandarins. To work in the Civil Service, all one needed was a first degree in History or Literature or English or Political Science. The above notion could still be prevalent among curriculum designers despite the fact that experience of all developed countries, indicate that Science and Technology are the basis of all development. The history of developed countries is really a history of science that builds technology leading to increased production capacity. However, it is necessary to be cautious when drawing a rigid dichotomy between Science and the Humanities. This is so because every academic subject is the study of Man and Humanity. According to Crick, “ we try to discuss just how the universe is constructed and in particular our place in it…..”.

We know that the ancient Egyptians followed by the classical Greeks, subsumed all knowledge under “Philosophy”. Thus any single book of Plato discussed Physics, Biology, History, Literature, Political Economy, Sociology and

Architecture. This holism is also true in Renaissance Italian such as Leonardo da Vinci and others. Lastly, a country that ignores Science and Technology is condemning itself to economic and intellectual stagnation for ever.

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# SCIENCE EDUCATION PROGRAMME – INITIATIVES OF THE INDIAN NATIONAL SCIENCE ACADEMY

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The science education programme had its genesis in the idea that INSA should be directly involved in the shaping of science education at the primary and secondary levels in producing adequate numbers of appropriately trained scientific and technological manpower has been recognized as one of the prime initiative by the Academy. The Academy has made several attempts in this direction and has been closely collaborating with international organizations and agencies. As a part of Inter Academy Panel activities, INSA has organised a programme on 'Science Education entitled – Trends and Future Initiatives'. This is essentially to focus on the efforts taken by various organizations in India and share their experience on science education in different environments with particular reference to school level. A brief report on the seminar including the suggestions and comments received from the participants is presented here[1].

The seminar was held in May 16-17, 2002 in New Delhi, prior to Asian Regional IAP seminar to present the efforts taken by various organizations in India in the area of Science Education. The seminar was mainly based on `experience sharing' in science education bringing together those responsible for improving curricula, science textbooks, educationists, teachers from both the formal and non-formal sector, those responsible for the professional development of teachers of science, those involved in assessment in science education and also those interested in science popularization and dissemination of science.

The Seminar was attended by 65 participants from 39 organisations, both government and non-government, who also displayed their initiatives in this area in the form of posters, science kits and books. Broadly seminar focused on science teaching (changing emphasis for teaching; professional development for teachers) and science contents in different branches of science; assessment in science education; science popularization and dissemination.

Participants were of the view that scientific institutions should adopt high schools and colleges, providing them requisite assistance. While mentioning about 5-10 centres for R&D in science education, the participants felt more are required. Besides the parents need to be sensitized about the career opportunities in science, the need for massive programme of teachers training and also how good were the testing tools in spotting talent, lack of reading materials and difficulty to produce good text books were needed to be tackled.

**The suggestions at the end of two-day interactive seminar are given below**:

- INSA, to have a dedicated website on science education in the country that would also help in networking individuals and organizations through knowledge exchange and experience sharing for the improvement of science education with special emphasis on taking science to the masses, and encouraging the participation of women towards careers in science. This would focus on issues such as experience sharing, towards improving science education in the country, information on use of experimental materials and inquiry based learning modules. Strategies would then be identified and implemented based on shared experiences.
- A collective meeting of all the science Academies of the country held in October, 2002. The meeting of October 24-25, 2002 is an outcome of the above meeting.
- India needs to overhaul its science education and improve its quality in general. Particularly, it must have a system designed broadly to suit its own needs and yet cater to different multicultural and multilingual needs that are unique to the country.
- Science education must reach the masses, the underprivileged and especially the girl child. Science education must evoke the natural curiosity of the child, the wonderment for Nature. For this, the education and its tools should be fashioned to the environment in which the child lives. The child should be encouraged to

find its own answers with textbooks being only a guide. Concepts must be introduced and field trips and outdoor activities to learn must be encouraged. At the school stage itself, there should be spotters to identify special talents for science and these must be further supported. The quantum of practical laboratory work, fieldwork must be substantially increased. To aid learning by inquiry more `exploratory' methods must be incorporated into the curriculum. A large number of experiments, kits and multimedia teaching aids should be created using as far as possible locally available materials with accompanying do-it-yourself books.

- Activities must be designed in full harmony with the child's environment and from this environment more detailed concepts of scientific truth must be got and understood. This would sensitize the child to its environment and help to solve niggling problems at a later date but makes the whole exercise of learning all the more interesting and invigorating. The do-not-touch mindset that is taught in the present system ought to change. Encouragement must be given to ask questions, understand the history of science, find how science is so entwined in their daily lives, feel the excitement for science and understand that there remains a lot to be still done.

- Curriculum at school and college level including university level must be periodically assessed and any resistance to change should be suitable thwarted. Textbook writing by senior scientists and teachers must be encouraged. The general quality of textbooks should be raised taking heed to the environment in which the child or student finds themselves in. Mathematics should be taught at all levels and must be mandatory for all science subjects or their combinations. Making mathematical construct rather than with pen and paper should be encouraged.

- School teacher training programmes must be increased all over the country and they should be given an opportunity to understand more recent developments taking place in their subject disciplines. This would help them to imbibe the same excitement in their students and raise the level of teaching. Spotters among teachers must be encouraged to spot talent early in each school at all district levels. The media, parents and students should be sensitized as to the various career options and job situations available to students coming out science streams. This would encourage more students to science and reverse the alarming trend of lack of interest for basic sciences.

- All kinds of possibilities to encourage and popularize science such as mobile vans, science centers, interactive exhibits, workshops and activity centres for children should be supported financially. Role of journals, popular science magazines in spreading the scientific temper among citizens must be more aggressively encouraged.

- Incentives for promoting science education in the country on a larger scale should be given. All science Academies must come together for the sake of improving the quality of science education in the country and play a more active role in the process of raising the scientific temper of the people of this country. The Academies should be a watchdog, leading the way for governmental policy issues that concern science education and help to change an outdated system.

1. The details are available in a book "Capacity Building in Science and Technology" published by Indian National Science Academy, New Delhi, India. Copies of this can be had by writing to the Executive Secretary, Indian National Science Academy, Bahadur Shah Zafar Marg, New Delhi 110 002, INDIA.

**SCIENCE EDUCATION**

**GENERAL CONSIDERATIONS**

**SCIENCE = FACTOR OF DEVELOPMENT**

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Actually, everyone recognize the positive impacts of science in development domain. So then, the whole world needs a kind of capitalist co-operation based on science because of disasters world is facing up to and numerous challenges we are making at the beginning of the 21st century. This partnership will be an advantage and has to help humanity to aim at peace, freedom and justice ideals.

We must ensure that we not only provide our young people with a top-notch education generally, but also provide them with a quality education in science specifically. We must help all students learn to frame questions that they can answer empirically. In other words we must help them to do science.

It is then necessary to encourage/ setup a new science education partnership program to recruit new science teachers and improve the teaching quality of our current teachers with the goal to produce a generation of superior scientists and engineers through increased funding for school laboratories, revision of science curriculum and new university scholarships for future scientists.

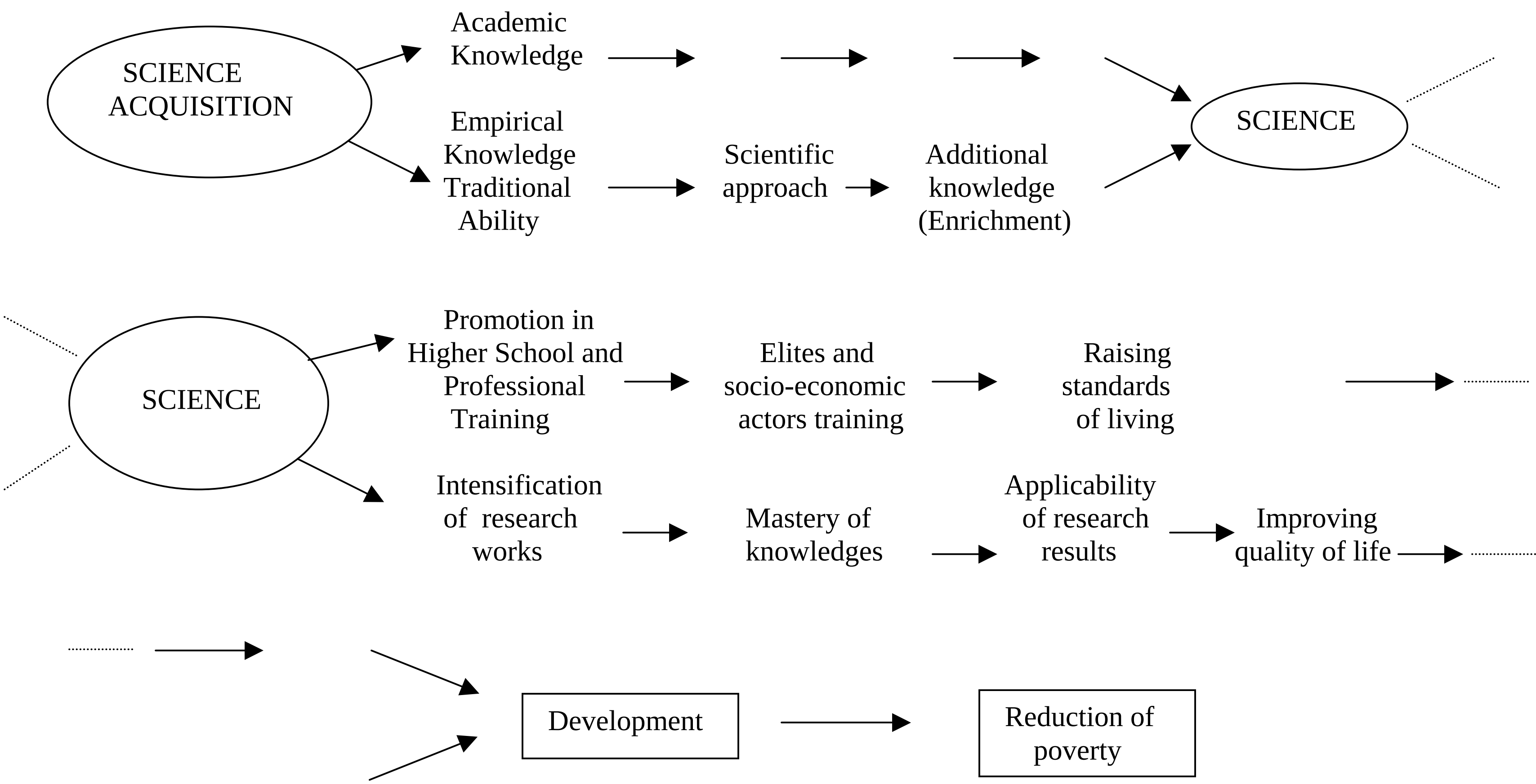
**It is time for a new major national effort to improve science education**. Usually the improving of the competence in science has been just for reasons of economics or national security. It should also be for personal well being and for the well being of our democracy.

Science brings order, harmony and balance to our lives. Everyone can learn science and excellent teaching can be learned.

So, join science to training, on one hand, to production and life, on the other hand, should be the aim of scientists decision-makers and all the participants in development who want to change the third world.

By summarising. One can say that,

Science must be included in any mandated program of educational assessment. Science, well learned, is a requirement for the workforce of the 21$^{st}$ century as well as for informed citizenship. Further it is well documented that assessment influences what is taught, both in terms of hours spent and in the nature of classroom activity. Any testing or assessment should be designed so that it not only encourages time spent on science but also motivates teaching methods that recognize that science is more than a body of facts. Students must also learn the methods of observation and experimentation and the modes of thinking that are used to discover and Test scientific knowledge.


SCIENCE ACQUISITION
Academic Knowledge
Empirical Knowledge Traditional Ability
Scientific approach
Additional knowledge (Enrichment)
SCIENCE
SCIENCE
Promotion in Higher School and Professional Training
Elites and socio-economic actors training
Raising standards of living
Intensification of research works
Mastery of knowledges
Applicability of research results
Improving quality of life
Development
Reduction of poverty

## EDUCATION AND SCIENCE IN TURKMENISTAN

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Turkmenistan is located in Central Asia.mm Its territory is 499,000 sq.km. With a population of about 5 million, 74% being Turkmen. 80 of its territory is desert with dry hot climate. Croup growing is possible only under irrigation. The main source of irrigation water being the Amu-Darya river.

At the beginning of 1995, there were about 1890 schools in Turkmenistan where one million boys and girls were studying. Among the main directions of the programmer "Bilim" was teaching three languages – Turkmen, Russian and English.

At present there are 14 institutes of higher learning in Turkmenistan: the state university and following higher educational institute-medical, polytechnic, agriculture, pedagogical; institutes of economy, transport and communication.

The desert research institute founded in 1962 has become a recognized international center for the arid land investigation and desertification control. Since 1967, the institute has been publishing an international journal " Problems of Desert Development" which since 1980 is being translated, published and distributed. In English speaking countries by the US Publishers "allerton press".

Research institutions and some scientists have broad regional and international links, institutional and personal. Exchange of information, joint projects, conferences, symposia, meetings in different branches of science are being carried out. Monographs, papers and scientific journals are being constantly published.

**OBSERVATION OF K. AHAMAD MALIK**

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In Germany, we have several nation wide programmes which focus on issues related to science teaching, learning and even research at school levels. Typical is a "Jugend Forscht Competition". This programme was created in 1965 with the aim of encouraging young (would be) scientists and engineers in Germany. The idea behind it is to support motivated and gifted young people at school and college level and assist them in finding a career to suit their talents. The competition is opened to young people aged up to 21 and country-wide so far more than 100.000 young students took part in it.

At the DSMZ and our parent organization GBF also several programmes are offered related to science teaching, learning and research at school and university levels. BIOS, is biotechnology laboratory programme, only available to students to develop their own methodological and experimental models in our premises.

As a Fellow of the World Academy of Sciences (WAAS) and the Member of the Education Committee of WFCC since 1985, I have personally been actively involved in the development of science curriculum of young scientists of developing countries through various International Training Courses and the publication of UNESCO/WFCC, Technical Information Sheets.

The tentative scientific programme of the Seminar appears to be very relevant to the needs of the developing countries and I hope that the outcome of our discussions will result in some concrete actions for promoting science education at school levels of the region.

A message from the President of Academy of Science of Afghanistan

**TRANSITIONAL ISLAMIC STATE OF AFGHANISTAN**
**ACADEMY OF SCIENCES OF AFGHANISTAN**

***Abdul Bari Rashed***
(Academy of Science of Afghanistan)

(By the name of Almighty Allah who is kind and merciful)

Your Excellencies chairman and members of federation of Asian Academy of Sciences and Societies and President of Indian National Science Academy, Endeared Erudite and hosts:

I take pride to offer warm thanks on behalf of Academy of Sciences of Afghanistan, zealous Afghan people and myself for your dignified nation upon my presence in this special meeting.

I hope that this conference, commenced with high scientific and humanitarian goals come to end with great and useful gains.

**Erudite and aware friends**

Certainly the respectable members of Federation of Asian Scientific Academies and Societies have gained thorough information from the statements and reports of previous years of Academy of Sciences Afghanistan in conferences and there is no need to review former notices. Academy of Sciences of Afghanistan had a culture mutual relations with some of Academies of science and research centers of world countries in old days, but unfortunately these relations were broken off due to unexpected and imposed events in our country and has lost its material and spiritual possessions from research appliances to spread and monitoring.

In spite of having material and spiritual losses Academy of Sciences of Afghanistan with bravery of these patriotic teachers have not surrendered themselves to compulsory programs of politics (escaping memory) and were able to present themselves by offering, brochures, conferences and scientific seminars as national and international and keep his administrative identification and independent science.

By this way Academy of Sciences of Afghanistan with all recent difficulties managed to form two great parts (Humanitarian Science and natural science) apart from keeping former formation with scientific centers, institute and related departments of other part by the name of research Islamic Science with centers, institutes and special departments in its frame works in order to extend Scientific research of Academy of Sciences of Afghanistan, but to struggle with this for standing of knowledge and research in, Academy of Sciences of Afghanistan urgently need bilateral reaching and cooperation of all research scientific foundations and region erudite for material and spiritual rehabilitation.

Academy of Sciences of Afghanistan expects from FASAS to have bilateral cooperation such as in allocation of educational and research fellowships, exchange of erudite views for research, for completion work of Ariana Encyclopedia, rehabilitation of buildings, monitoring books and research appliances, laboratories and provision of transportation and particularly in using of Bio gas and now – how technology.

Dear erudite and researchers,

Let me avail this opportunity and offer proposal, which stands interesting for discussion of most people.

**The sign of question is still remain on the board of Philosophy and politic regarding the real respiration issue.**

Everyone make effort to attain his/her goals of inward and outward, but unfortunately in spite of having lots of victimization and great economical scientific gains we can find fewer to stand in humanitarian community and considers himself in basic aspirations and demands.

The nation wish to gain freedom, independence, welfare, fraternity, equality, justice, absence of discrimination and egotism even external and internal calmness. The problems of science and technology have been solved as far as the urgent needs of people.

But to strive for acquiring of knowledge to the highest stages mankind would try his best to follow the duty that God has chosen forever.

We hope that scholars of scientific departments and human research centers particularly members of (FASAS) shall research to rescue people from moral and human motives beside scientific and vocational exploration.

Therefore, I summon the members of this year conference of FASAS for obtaining scientific responses for two vital questions, for person and society.

2. Why most people have not achieved their goals with all these science and technology and upgrading of material life to humanitarian demands such as freedom, independence and social justice as real till now?
3. Why mankind has faced with some interminable and bothering struggles inwardly and doesn't feel calm in any marital statuses such as being single or married in economical, social, political and scientific positions.

We hope that endeared explorers and responsible of (FASAS) would be able to present international seminars in this connection and answers these kinds of questions for settlement of social and individual.

Academy of Sciences of Afghanistan positively declares its readiness for asserting of opinions and participation in such seminars through this global tribute.

## CONCLUDING SESSION

The two-day Asian Regional IAP Seminar on the Generation of Experimental Materials and Learning Modules for Science Education provided a meeting place for interactive discussion and deliberation on the various initiatives taken by the Academies in the different countries in this region. There is certain unanimity in views expressed by different countries. The Science Education is for all. Science education is important in the economic development of the country and to sustain the quality of life of every citizen. The development of science should be an organized social activity with equal participation from science educators, children and society in which they live in. Though science is international in character, no unique model of science education is applicable. Models should evolve depending on the geographic location, environment, technological development and nature of societies in the different regions. Scientific literacy among citizens is another important feature and this can be accomplished through participation of the media with governmental and non governmental support.

The difficulties and constraints experienced by different countries in the administration of science education in schools are very similar. These pertain to over crowded classes, inadequate number of trained teachers, lack of teacher training facilities, absence of continuing education programme for in-service teachers, non availability of teaching materials (especially training facilities, absence of continuing education programmes for in-service teachers), non availability of teaching materials (especially laboratory experiments), inadequate contact hours (teacher-students) and others. Another aspect is the populace to be educated. The children come from different regions (rural, urban and remote areas), economic factors (deprived and non deprived) language groups.

The design and development of science curriculum in different countries had certain commonalities. The topics of teaching relate to health and hygiene, environment (flora and fauna) pollution, weather and climate, agriculture (plants and their usefulness) and others.

The science teaching, however, should be linked to performing experiments and observations of results followed by classification of facts. The experiments chosen should make use of locally available materials and cost effective.

Much has been said and written by many participants about the declining number of and disappointing lack of diversity among school and college children taking science as a career. Among the several reasons advanced, it is recognized that science is not an attractive career in relation to medicine, business, information technology and others. It is possible to rectify this misconcept by proper science education and wide range of application of science in different professional activities.

This meeting brought forth an important feature of outsourcing science education. This involves the necessity of good number of science parks, science museums, mobile library, mobile science laboratories, availability of popular and attractive books/monographs/leaflets, utilization of audio and visual media presentation enabled by IT, science contests and exhibitions at rural/district/state and national levels and others.

It emerged from the meeting that there is a gender bias in science education in this region. Very few girl children take science as a subject of study. Efforts should be made to involve them in science learning and technology. It is recognized once a good number of girls take up the science profession, it will have a multiplier effect since they inculcate science in their children.

**SCIENCE EDUCATION PROGRAMME- INITIATIVES OF THE INDIAN NATIONAL SCIENCE ACADEMY**

**October 24-25, 2002, Banquet Hall,**
**Ashok Hotel, New Dehli**

<u>Organised by</u>

The Indian National Science Academy

Indian Academy of Sciences

National Academy of Sciences of India

The Mexican Academy of Sciences

The French Academy of Sciences

Inter Academy Panel

Inter Academy Council

**PROGRAMME**

***October 24, 2002***

09.00 hrs. :Welcome - V. Krishnan, Vice-President, INSA (Convener)

09.15 hrs. : Address – G. Mehta, Immediate Past President, INSA

09.30 hrs. : Key Note Address – C.N.R. Rao, President, TWAS

**10.30 hrs** ***Tea Break***

11.00 hrs. : ***Session I***: (Chair: E.M. Krieger, President, Brazilian Academy of Sciences, Co-Chairman: A.O.E. Animalu, President, Nigerian Academy of Sciences)

i) **China**: Professor Zhu Qingshi, Chinese Academy of Sciences

ii) **Bangladesh**: Innovations in Science Teaching by Shamsher Ali, President, Bangladesh Academy of Sciences

iii) **USA**: Sally Goetz Shuler, National Science Resources Centre, USA

iv) **Korea, Rep**: Yung-Woo Park, The Korean Academy of Science and Technology

12.20 hrs. : French Experience: Pierre Lena/Y. Quere, Pontifical Academy of Sciences/French Academy of Sciences

12.50 hrs. : Chairman/s Remarks

**13.00 hrs** : ***Lunch Break***

14.00 hrs. : Open Form on Asian Initiatives

16.00 hrs. : ***Tea Break***

16.30 hrs : ***Session II*** : (Chair: Bruce Alberts, President, NAS-USA, Co-Chair: Zhong-Xian Zhao, Institute of Physics, CAS, China)

i) **Vietnam**: V. Duc Dao, Instt. Of Physics, National Centre for Natural Sciences & Technology

ii) **Thailand**: C. Arthachinta, Secretary-General, National Research Council of Thiland

iii) **Philippines**: Filma G. Brawner, Deputy-Director, DST, Manila

iv) **Malaysia**: The Role of Academy of Sciences of Malaysia in Science Education by Augustine S.H. Ong, Fellow Academy of sciences, Malaysia

17.50 hrs : Presentation by E.M. Kreiger, President, Brazilian Academy of Sciences

18.20 hrs. : Chairman’s Remarks

20.00 hrs. : ***Dinner***

**October 25, 2002**

9.00 hrs : ***Session III*** : (Chair: Y. Quere, Foreign Secretary, French Academy of Sciences, Co-Chair: J.R. Tata, U.K)

i) **Nepal**: D. Bajracharaya, President, Royal Nepal Academy of of Science & Technology

ii) **Afghanistan**: Abdul Khalil, Afghanistan Science Academy

iii) **Pakistan**: Riazuddin, National Centre for Physics, Quaid-I-Azam University, Islamabad

iv) **Sri Lanka**: J.N.O. Fernando, Past General President, Sri Lanka Association for the Advancement of Science

10.20 hrs : **Presentation by**: J.L. Moran Lopez, Mexico

10.50 hrs. : Chairman’s Remarks

11.00 hrs. : ***Tea Break***

**11.30 hrs.** : ***Session IV***: (Chair: R D. Ardakani, President, Academy of Sciences, IR Iran, Co-Chair: M.A. Peerally, Vice-President, African Academy of Sciences, Mauritius)

- i) India: V.G. Bhide, Formerly Vice-Chancellor, Poona University
- ii) India: NCERT experience in the field of Science Education by R.D. Shukla, National council for Education Research & Training, New Delhi
- iii) India: Arvind Kumar, Director, Homi Bhabha Centre for Science Education

12.50 hrs. : Taiwan: Chang-Hung Chou, President, National Pingtung University

13.10 hrs. : Chairman's Remarks

13.20 hrs. : ***Lunch Break***

***Session V***: (Chair: Thomas R. Odhiambo, African Academy of Sciences, Co-Chair: E.N. Sabiti, Makerere University, Kampala, Uganda)

14.30 hrs. : **African Experience**: J.O. Malo, Chairman, The Kenya National Academy of Sciences

15.00 hrs. : **Chairman's Remarks**: Thomas R. Odhiambo, African Academy of Sciences

15.30 hrs. : ***Tea Break***

16.00 hrs. : Panel Discussion: Coordinator – G. Mehta

17.00 hrs. : Vote of Thanks by V. Krishnan, Convener

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