Teaching and Learning of Science in Schools
(Republic of Mauritius)

VOLUME I

Recommendations and Action Plan
(2004 – 2006)

May 2004

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Mauritius Research Council
May 2004

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LIST OF ACRONYMS

ICT	Information and Communication Technology
MCA	Mauritius College of the Air
MES	Mauritius Examination Syndicate
MESR	Ministry of Education and Scientific Research
MIE	Mauritius Institute of Education
MRC	Mauritius Research Council
NCCRD	National Centre For Curriculum Research and Development
PSS	Private Secondary Schools
PSSA	Private Secondary Schools Authority
STL	Scientific and Technological Literacy
TC	Teachers' Centres
UOM	University of Mauritius
UTM	University of Technology, Mauritius

TEACHING AND LEARNING OF SCIENCE IN SCHOOLS OF MAURITIUS

Recommendations and Action Plan

BACKGROUND

The Mauritius Research Council, in its capacity as the adviser to Government on all matters pertaining to science and technology, undertook a number of studies (see Annexes 1-5) with a view to assessing the status of science and technology in Mauritius, in general, and more specifically, in the educational sector. With regard to the latter, the findings of these studies call for concern, as increasingly science is becoming less attractive in the schools. As a result, fewer than 30% of 'O' level students would actually opt for science in the secondary schools. Many reasons were advanced as to why students shy away from science. These range from the subject being perceived as difficult to meant only for the bright ones and lack of job opportunities. The findings also indicate that Public Understanding of Science is on the decline.

It was in the wake of these studies and following the submission of a Draft Action Plan for Science Education (see annex 6) that the Ministry of Education & Scientific Research mandated the Council to Chair a Steering Committee to make recommendations, in the light of the findings of the reports. Subsequently, two Task Forces, one for the primary sector and one for the secondary sector, were set up. These committees comprised of all stakeholders, including teachers, trainers, inspectors, head teachers, rectors and trade union representatives (see enclosed lists at pages II and III). The committees met on numerous occasions and deliberated on matters centred around the issues of – What kind of science should we be teaching in the Mauritian context? How should one teach science? Who should do the teaching? And finally how should the teaching and learning of science be assessed?

In addition to the above studies, the Council commissioned a number of surveys (see Annexes 7-8) to further assess the teaching and learning of science at schools. In particular, the views of the general public was sought through advertisements in the local papers and through the Council's website.

The recommendations and Action Plan presented in this report emanate mostly from the findings of the studies and surveys carried out and from the many deliberations of the Steering Committee and the Task Forces. The detail findings of the studies are found in Volume II of this report.

These recommendations have also been validated by a sample of the stakeholders, namely teachers, head teachers, rectors and inspectors, among others, and have been adopted.

The first section of the report focuses on the issues pertaining to the teaching of science at the level of primary schools and the recommendations made thereafter. Section B deals with the issues and recommendations for the secondary sector. In Section C, common recommendations are formulated for both sectors.

The last section presents a two-year Action Plan which translates the recommendations into projects to be implemented by the stakeholders in the education sector.

A: SCIENCE EDUCATION IN PRIMARY SCHOOLS

A.1 THE CURRENT SCENARIO

The studies pertaining to the status of science teaching and learning in primary schools revealed certain weaknesses in the primary sector in terms of

- purpose of teaching science
- quality of science curriculum
- teaching and learning approaches currently being practised
- time allocation to teaching science in schools
- facilities for teaching science
- training of teachers
- medium of instruction for teaching science
- assessment and examination systems.

There is an urgent need to address the above issues to improve the quality of science teaching for the social and economic development and prosperity of the Republic of Mauritius. The current approaches to teaching and learning of science have to improve to prepare the nation to meet the challenges being presented by the rapid pace of technological change and the globalization of the marketplace.

A.2 CASE FOR DEVELOPING SCIENTIFIC AND TECHNOLOGICAL LITERACY

In the primary schools of Mauritius science is taught as Environmental Studies from Standard 1 to Standard 3 and as basic science from Standard 4 to Standard 6. A spiral approach to curriculum development has been followed. Local textbooks have been produced based on the curriculum. The spiral approach to curriculum has brought about coherence, but the presentation lacks essential relevance. Although a lot of activities has been provided in the textbooks for the pupils to do practical or activity based work, practical sessions are hardly conducted.

The written English text in science books is generally difficult and is not consistent with the level of vocabulary used in English textbooks for a particular class. Many students may find science difficult and lose interest in science because of the difficulty of language alone.

The science curriculum focuses on developing scientific concepts, which could be memorized and recited in the examination. Science-and-technology is often seen as a single entity, hence some understanding of technology is fundamental to the development of scientific and technological literacy. This approach will enable students to understand the relationship between science and technology and the interdependence between the two of them. It will further provide opportunities and experiences to the pupils in the context of the impact of technology on people's lives and on the physical environment.

Mauritius has long moved from a policy of labour intensive to that of capital intensive economy with a view to creating a knowledge-based society. A variety of electronic goods and the Mobile phone are now in almost every household. In the market place people are required to make informed choices between artifacts, which require an understanding of science and technology. Society at large is being exposed to a lot of information and issues, which increasingly contains elements of science and technology.

Science literacy is nowadays a must in order for one to comprehend the world and be able to contribute positively to its development. Furthermore, with the increasing importance of ICT and realising that one can not develop competent ICT skills without a good science foundation and particularly mathematics, the teaching and learning of science becomes a prime consideration for the development of human capital.

It is therefore essential that in order to make informed choices and to live and contribute in this ever growing technological world our young people should have competencies and skills in science and technology. Keeping the goal of developing scientific and technological literacy in mind the aims of science education at the primary level should be to:

- prepare young people to acquire a broad understanding of the main ideas and processes of science,
- enable students to understand procedures of scientific inquiry and apply new knowledge to solve problems,
- understand and appreciate the interdependence between science and technology and the way technology is impacting human life,
- develop the curiosity and inquisitiveness of young people about the natural and physical world around them, and build their confidence in making inquiry into their behaviour,
- acquire further knowledge from a variety of sources when required.

RECOMMENDATION 1:

It is recommended that

1.1 the aim of science teaching at primary level be redefined to include development of scientific and technological literacy (STL).

1.2 the current primary science curriculum be reviewed and revised to incorporate technological aspects with the objective of developing scientific and technological literacy. Consultation with stakeholders will benefit the review.

1.3 science textbooks must be reviewed from the language point of view and simplified such that the English vocabulary used is as far as possible consistent with the vocabulary expected at that level.

1.4 personnel associated with curriculum development would benefit from training in designing curriculum and writing textbooks.

A.3 IMPROVING TEACHING AND LEARNING

Although Science appears to be popular among pupils in the primary sector, a didactic approach continues to be used in most schools mostly because of the following reasons:

- lack of science equipment/kits and science rooms;
- crowded classrooms;
- teachers' lack of confidence in science teaching;
- rigid timetable;
- assessment procedures reinforcing memorization of facts and content;
- heavy workload of teachers;
- lack of effective professional development programmes for teachers; and
- absence of resource materials for teachers to support them in teaching.

This situation has to change to achieve the goals of science teaching and to make it interesting and rewarding. There is a need to use more child-centered, active learning approaches to develop thinking, reasoning and problem solving skills involving practical work.

RECOMMENDATION 2:

It is recommended that a child-centered, active learning approach be used in teaching science to develop thinking, reasoning and problem solving skills amongst children.

A.3.1 Practical work

As practical work is expensive and time consuming, teachers need to be very clear about the intended learning outcomes. Practical work should be enjoyable and at the same time promote excitement and investigative skills. It should be possible to perform most of the practical activities at the primary level using materials from the environment (school, home and community) which pupils could bring with them provided teachers plan their lesson in advance and inform pupils of material requirement. There will however be the need of some inexpensive basic science equipment. Group activities over individual activities must be promoted at the primary level enabling pupils to pool their ideas, learn cooperatively and to build a team spirit. Effective practical work at the primary level should allow students to:

- gain first hand experience of scientific equipment, materials, living things and artifacts;
- practise basic experimental skills such as observation, measurement, controlling variables and manipulation in different contexts;
- observe and understand phenomena through carrying out experiments or watching teacher demonstrations;

- learn how to work safely and responsibly; and
- work together in groups.

Currently there is little evidence of science teachers performing and planning practical work with the objective of enhancing students learning or achievement. In order to promote and facilitate group practical work at the primary level a separate science room is an important requirement.

RECOMMENDATION 3:

3.1 It is recommended that group practical work should be promoted at the primary level, which could be performed using materials available locally in the environment and at home.

3.2 Immediate steps should be taken to support schools, which have an extra room to set it up as a science room.

3.3 Alternative models of creating additional space for science room, including sponsorship of the private sector must be investigated for schools that do not have a science room.

A.3.2 Medium of instruction

Primary school teachers are facing difficulty in making pupils understand concepts of science in English, which is the official medium of instruction. The reason is that the English vocabulary is not yet well developed at this stage. As a result, many if not most teachers resort to use the mother tongue to explain scientific terms.

RECOMMENDATION 4:

To overcome the difficulty of language in teaching science at the primary level, it is recommended that

4.1 At the beginning of each chapter explanations/definitions of scientific/technical terms be included which teachers should go over first with students before starting the chapter.

4.2 Maternal language or most commonly used or most easily understood language could be used to explain science concepts, but as per the current practice English should continue to be used for all written work in science.

A.3.3 Specialist teachers to teach Science, Mathematics and ICT

The current practice of teaching science in primary schools by General Purpose Teachers, a lot of whom have studied science only up to Form 3, is not conducive to creating interest and excitement in pupils learning science. Since ICT has also been introduced as a school subject at the primary level, it will immensely contribute to

the quality of primary education if a specialized teacher could teach science, mathematics and ICT in each school. These three subjects form a natural cluster requiring similar aptitudes and could be taught by the same one teacher. The number of such specialized teachers in a school will depend on the school population and number of periods for these three subjects. The qualifications of such a teacher should be such that one teacher should be able to teach all three subjects. This would lighten the current workload of the General Purpose Teachers who could use the time for improving teaching in other subjects. This may have a knocking effect on improved teaching of other subjects at the primary level.

RECOMMENDATION 5:

It is recommended that specialized teachers to teach science, mathematics and ICT (a natural cluster of subjects) be appointed in primary schools. It is envisaged that one duly qualified teacher would be able to teach all three subjects.

A.3.4 Time Allocation for Science Teaching

Currently three periods of 25 minutes each, i.e. 75 minutes per week, out of a total of 25 hours school working week are allocated to the teaching of science. This shows that only 5% time is allocated to the teaching of science per week in primary schools. A period of 25 minutes is not conducive to carrying out practical work or even a useful demonstration, which is essential for quality science teaching. This time is not sufficient compared to international standard where a minimum of 10% time is allocated to the teaching of science, especially from Standard 3 onwards.

RECOMMENDATION 6:

It is recommended that science teaching be allocated a minimum of 5 periods per week with at least one double period a week to enable students and teachers to undertake practical work in science, including hands-on activities and/or viewing science films.

A.3.5 Assessment of the Science subject

Assessment forms an integral part of the teaching and learning process. It determines both the mode of teaching and the manner in which pupils undertake learning. The one-off end of year examination that determines the pupil's grade may not be the most appropriate and fair assessment of the pupil's abilities and is conducive to rote learning.

With regard to assessment of practical or activity based work, it is not feasible to have individual assessment at the primary level. In this case, the focus should be on group activities, continuous assessment and group assessment.

RECOMMENDATION 7:

It is recommended that

7.1 A weightage for continuous assessment be added to final examination to calculate final grade/score to be awarded to a student. It is recommended that the final score/grade should be based on 40% weightage to continuous assessment and 60 % to final examination.

7.2 For the group practical work the effort of the group must be assessed and grade/marks assigned to the whole group. Each member of the group would receive the same marks/grade as to the whole group.

7.3 A system of moderation be introduced to achieve consistency and fairness in assessment.

7.4 Assessment materials in the form of question bank in science be produced on a national basis, designed to measure progress and achievement against very clearly defined objectives. To achieve consistency in assessment, standards of acceptable responses will have to be clearly defined in the form of marking schemes.

The proposal to develop question banks and marking schemes is likely to bring about a number of benefits, including the following:

- Science teachers would understand better what to teach and students would know what to learn; it would improve the quality of teaching and learning.
- Nationally developed assessment materials would provide teachers with a reliable and consistent means of confirming their judgments about students' knowledge and understanding of key concepts and processes in science.
- It would help to ensure continuity and progression in learning for learners moving from primary to secondary schools because there would be valid and reliable evidence of students' knowledge, understanding and skills for secondary teachers to build on.
- A pupil "assessment card" could accompany each student during the school years from primary to secondary. Such a card would clearly indicate the individual strengths and weaknesses so that each pupil would be able to benefit from any special attention required from the teacher.
- Well-designed assessment of the pupils' knowledge, understanding and skills would provide reliable evidence about the effectiveness of the science programme, which could be used for raising standards.

A.4 PROFESSIONAL DEVELOPMENT OF TEACHERS

The findings of the studies show that most primary teachers lack confidence in science teaching since a lot of them did not study science beyond Form III. Some in-service training programmes are organised by the staff of School of Science and Mathematics of the MIE and some by the School Inspectors, but they are infrequent.

A majority of teachers have described these courses as unsatisfactory. Until specialized teachers are appointed to teach science, mathematics and ICT, there is a need for regular, frequent and quality in-service training programmes for existing teachers to develop their competency in teaching science. Special training modules must be designed regarding the organisation of group practical work and its assessment as well as for the teaching of science with the objective of developing scientific and technological literacy.

Research evidence supports the view that there is a correlation between increasing teachers' own understanding of science and improving the quality of their teaching of science. Better understanding of science concepts including practical work by teachers leads to the selection of better teaching strategies, which result in better understanding of scientific concepts by learners.

There is a lack of essential resource materials for teachers and students in the form of Teachers' Guides and students' workbooks which could support teachers in teaching science. These could be very useful resource materials in the hands of teachers especially when they do not have sufficient background in science.

To break the professional isolation of teachers there is a need for them to share their experiences with their colleagues. Sustainable mechanisms for continuous professional development and support are required for teachers to build their confidence in science teaching.

Given the importance of science education in the school curriculum, many countries have School Science Inspectors to supervise, support and promote best practices in science teaching in schools. It would appear that some General Purpose School Inspectors, who had themselves not studied science beyond Form 3, are involved in-service training of teachers.

RECOMMENDATION 8:

It is recommended that

8.1 Regular, frequent and quality in-service training programmes be organised for existing primary school teachers to develop their confidence in teaching science, and assist them in organising group practical work, including group assessment.

8.2 Teachers' Guides and students' workbooks must be produced to support teachers in their efforts to improve the quality of science teaching.

8.3 Primary School Science Coordinators be appointed to supervise, support and promote best practices in science teaching in schools. The qualifications and experience of the Coordinators should be such that they should be able to supervise teaching of science, mathematics and ICT.

B: SCIENCE EDUCATION IN SECONDARY SCHOOLS

B.1 THE CURRENT SCENARIO

The studies conducted for the secondary sector revealed the following issues:

- Science is perceived as difficult and meant only for bright pupils.
- Perceived lack of career opportunities.
- Less than 30% of pupils opted for science at O level in recent years.
- About 20% of pupils took computer studies at O level in recent years.
- About 5% of pupils took computer studies at A level in recent years.
- Extremely few girls are attracted to physics.
- Lack of infrastructure for practicals.
- Training of Laboratory Assistants.
- Science not an option in some schools.
- Science curriculum to be locally relevant.
- "Alternative to Practical Exams" not conducive to the development of practical skills.

B.2 CASE FOR COMPULSORY SCIENCE UP TO FORM V

For a large number of young Mauritians education in science is an end-in-itself, when they complete their Form 3 (age 14 years). This little education in science does not develop in the youth (a) an ability to make informed decision whether to choose the formal study of science beyond 14 or not; and (b) the knowledge, understanding, skills and competencies required of a scientifically and technologically literate citizen. Due to these considerations, science is a compulsory subject in most developed countries (e.g. Australia, Canada, France, Germany, Sweden and UK to name a few) and developing countries (e.g. India, Botswana, Malaysia, Nigeria and South Africa) up to the age of 16 as part of general education. In most countries specialization begins only after the age of sixteen.

In addition to the above, the following considerations further support the proposal to make Science compulsory up to Form V:

B.2.1 Human resource is a significant resource for the diversification of the economy of Mauritius.

B.2.2 Mauritius has launched itself into becoming a cyber island and needs well-qualified human resource.

B.2.3 Good understanding of science and technology, including mathematics, is essential to the social, economic and technological development of Mauritius to achieve its goal of becoming a cyber island.

B.2.4 Good knowledge and understanding of science and scientific ways of thinking is necessary to function confidently and effectively in a global and technologically evolving society.

B.2.5 Scientific and technological literacy is essential for all to interpret and understand what they see and read in the media, messages of scientific nature, which could be conflicting and have social, moral and ethical implications.

B.2.6 With the rapid pace of technological advancement, individuals come across, and get opportunities, to use new products and services at home, at work and during their travel abroad. Teaching of science and technology would prepare them to use and contribute to the improvement of such products and services.

B.2.7 As responsible citizens in a democratic society, they should be able to evaluate and make judgment about the benefits and risks associated with developments in science and technology and their applications. They should also be able to participate with interest and engage themselves in the debate on the issues posed by science, environment and technology which have implications both for them individually and society as a whole.

B.2.8 To meet the challenges of globalization and to keep Mauritius relevant in the knowledge economy.

B.2.9 To meet the demand for competent science and technology teachers, especially at the primary level, which is currently in short supply.

RECOMMENDATION 1:

It is recommended that

1.1 A policy decision to have compulsory science[1] for all pupils up to Form V. This would imply that in the current system, those pupils choosing only one Pure Science[2] or no science subject at all at Form III, will have to study the compulsory science subject.

1.2 The content and structure of the compulsory science up to Form V should be locally relevant (Mauritianised) and prepare youth to be scientifically and technologically literate.

1.3 The content and structure should also provide a firm basis for those wishing to continue science beyond Form V, a need that could be met by a bridge-science foundation course.

[1]Compulsory Science – the new science curriculum, which will be more applied and locally relevant.
[2] Pure Science – the existing Physics, Chemistry and Biology modules being offered at Form V level.

B.3 RESTRUCTURING THE SCIENCE CURRICULUM

Statistics shows that a large proportion (about 70%) of students drop Science as a subject after Form 3, when they have to choose their field of studies.

Currently, in Form I and II Science is taught in an integrated manner and in Form III, Science is taught as three separate components, Chemistry, Physics and Biology. The findings of the studies indicate that it is precisely this change in structure which occurs from Form II to Form III that brings about the perceived difficulties and abstraction of Science by the students. It appears that a gap in knowledge is created while changing the structure of the subject from its integrated form to its separate components. This is a fundamental flaw that needs to be remedied.

Since the goal of science teaching up to Form V is to develop scientific and technological literacy, the science curriculum for secondary education will have to be reviewed and revised keeping that goal in mind. First of all this will require a clear definition of objectives of science education. The Task Force for Secondary Science Education has already stated some objectives of science teaching at that level (see Annex 9) which could form a basis for reviewing and revising the science curriculum. It is clear from the definition of the objectives of science teaching and the topics suggested by the Task Force that it is proposing to teach science as physics, chemistry and biology starting from Form I, while introducing a large dose of Mauritianisation of the curriculum. This would also address the issue of training teachers to teach all aspects of Integrated Science, which can be problematic. The inclusion of technological topics in the suggested curricula is a further recognition of the need of integrating technology with science to develop scientific and technological literacy.

Although the focus of science teaching from Form I-V will remain on developing scientific and technological literacy, yet the study of physics, chemistry and biology will enable pupils to develop a sound foundation to study science at the HSC level if they wish to do so.

Furthermore the secondary science education programmes should develop the skills of creative thinking and problem solving. Science courses must provide sufficient scientific and technological knowledge, understanding and skills enabling students to understand newspaper reports, TV and radio programmes about scientific, technological and environmental issues. The science curriculum should also develop competencies that would enable youth to express their opinion on important social, moral and ethical issues with which they are confronted. Such a curriculum has to be relevant and contextual to the lives of Mauritian youth and society, which is currently lacking.

A review of textbooks shows that there is a content overload and little opportunities are provided to students to develop processes of science and apply their knowledge and understanding to solve problems.

RECOMMENDATION 2:

It is recommended that

2.1 A policy decision be taken to teach compulsory science as one subject comprising three modules - Physics, Chemistry and Biology from Form I–V with a focus on developing scientific and technological literacy.

2.2 The content overload should be reduced to give way to scientific enquiry through practical work.

2.3 Eventually, 'alternative to practical' exam to be banned.

B.4 IMPROVING TEACHING AND LEARNING

The survey points out that science teaching in schools is uninteresting and unexciting since didactic approach is mainly followed in most schools because of

- the syllabus being too examination oriented;
- the lack of science equipment/kits and science rooms;
- overcrowded classrooms;
- assessment procedures which encourage memorization of facts and content;
- practical work not being carried out; and
- lack of effective professional development programmes for teachers.

This situation has to change to achieve the goals of science teaching and to make it interesting and rewarding. Science courses at the secondary level should be able to sustain the interest and develop the inquisitiveness of learners. Computer software, including CD ROMs, and videos can provide a worthwhile learning resource and can make science live in the classroom and extend ideas beyond the confine of the curriculum.

RECOMMENDATION 3:

3.1 It is recommended that more active learning approaches to science teaching be employed to develop inquisitiveness, reasoning and problem solving skills amongst learners.

3.2 Greater opportunities must be provided for group work, use of multimedia packages and computer software, including CD ROMs, to promote independent learning amongst pupils.

B.4.1 Practical work

As practical work is expensive and time consuming, teachers need to be very clear about the intended learning outcomes. Practical work should be enjoyable and at the same time promote excitement and investigative skills. To carry out investigative practical work will require well-equipped science laboratories. The survey has revealed that practical work is sporadic in secondary schools and depends on the commitment of the teacher. The survey has also revealed that some schools lack facilities to conduct practical work. There also appear to be two norms of quality standards to benchmark science laboratories. The MESR norms are more stringent than that of the PSSA. A separate study commissioned by MRC indicates that none of the 99 Private Secondary Schools (PSS) satisfy the MESR norms. In addition, 16 PSS do not have laboratories and 45 PSS do not even satisfy the PSSA norms. The same study estimated that it would cost around Rs 25m to upgrade the PSS laboratories in order to attain the MESR required level (refer Annex 10). This situation is unacceptable since practical work is fundamental to the learning of science. It is the practical work which makes science different from other subjects. Group practical work will enable pupils to pool their ideas, learn cooperatively within multi-ethnic groups and to build a team spirit for mutual benefits. Effective practical work at the secondary level should allow students to:

- gain first hand experience of scientific equipment, materials, living things and artifacts;
- practise basic experimental skills such as observation, measurement, controlling variables and manipulation in different contexts;
- observe and understand phenomena through carrying out experiments or watching teacher demonstrations;
- plan, carry out, evaluate, and write reports on scientific investigations;
- learn how to work safely and responsibly, and work together in multi-ethnic groups.

RECOMMENDATION 4:

It is recommended that

4.1 Group practical work should form an essential component of science teaching right from Form I.

4.2 Laboratory facilities be upgraded in those schools where they are lacking.

4.3 Recruitment of qualified laboratory technicians and gradually phasing out the existing post of laboratory assistant.

4.4 Supply and Maintenance of laboratory equipment be decentralized and be managed at the regional level by competent units.

4.5 Alternative models of providing additional space for science laboratories, including sponsorship from the private sector, must be explored in those schools where laboratories do not exist.

4.6 In-service training programmes or other suitable training programes for laboratory assistants must be organised to make them effective resources to complement science teachers.

B.4.2 Assessment of Compulsory Science

The compulsory Science focuses on developing scientific and technological literacy. The emphasis is also on the Mauritianisation of the curriculum and the use of practical work. To achieve these objectives, the assessment should not be a one-off end of year examination which does not reflect adequately the learning abilities of the student.

Furthermore, in order to encourage peer learning and a sense of belonging, practical sessions should be undertaken in multi-ethnic groups. Similarly, assessment of practical work is to be based on group assessment for Form I, II and III. The group work and group assessment will also help to create an environment of partnership and teamwork which will further consolidate our social fabric.

RECOMMENDATION 5:

It is recommended that

5.1 The examination for Compulsory Science should consist of both theoretical aspects and practical sessions in each of the three modules, i.e., chemistry, physics and biology on a continuous assessment basis rather than end-of-the year examination.

5.2 For students in Form I, II, III as well as those taking compulsory science in Form IV and Form V, practical work should be assessed by group performance.

5.3 For students in Form IV and V who have opted for two or more pure science subjects (therefore do not undertake compulsory science), practical work should be assessed on an individual basis.

5.4 For students opting for pure science at Form IV and V, an appropriate weightage of the continuous assessment be added to the final examination score for the calculation of final grade/score. It is recommended that the final score/grade could be based on 40% weightage to continuous assessment and 60% to final examination.

5.5 In the continuous assessment of the group practical work, effort of the group must be assessed and grade/marks assigned to the whole group. Each member of the group would receive the same marks/grade as awarded to the whole group.

5.6 A system of moderation be introduced to achieve consistency and fairness in assessment.

5.7 Assessment materials in the form of question bank in science be produced on a national basis, designed to measure progress and achievement against very clearly defined objectives. To achieve consistency in assessment, standards of acceptable responses will have to be clearly defined in the form of marking scheme.

5.8 Assessment panel comprising of group of teachers from different schools to be established by MIE and MES to conduct external reviews and assessment.

The proposal to develop question banks and marking schemes is likely to bring about a number of benefits, including the following:

- Since teachers would better understand what to teach and students would know what to learn it would improve quality of teaching and learning.
- Nationally developed assessment materials would provide teachers with a reliable and consistent means of confirming their judgements about students' knowledge and understanding of key concepts and processes in science.
- It would help to ensure continuity and progression in learning for learners moving from primary to secondary schools because there would be valid and reliable evidence of students' knowledge, understanding and skills for secondary teachers to build on.
- Well-designed assessment of students' knowledge, understanding and skills would provide reliable evidence about the effectiveness of the science programme, which could be used, for raising standards.

B.5 PROFESSIONAL DEVELOPMENT OF TEACHERS

There are very few opportunities for science teachers to meet on professional basis and share their experiences. There are virtually no teachers' Guides to support them in teaching science. There are no School Science Inspectors at the secondary level to supervise, support and share best practices in science teaching. The new approach to science teaching, which focuses on development of scientific and technological literacy, would require in-service training of all teachers.

During the implementation of the new vision for science teaching, it will be very helpful if opportunities are provided to teachers to meet regularly to share their experiences and learn from peers. Sustainable mechanisms for continuous professional development and support for teachers are needed to build their confidence in implementing the new vision for science teaching. Establishment of Teachers' Centers, whereby teachers could regularly meet for professional exchange, could be explored. Each Teacher Center (TC) could cater for 10-12 schools. Each TC could be located in one of the schools. Such Teachers' Centers are functioning successfully in India, Nigeria and Zambia and are being established in many other countries.

RECOMMENDATION 6:

It is recommended that

6.1 Regular, frequent and quality in-service training programmes be organised for science teachers to develop their confidence in teaching science for the promotion of scientific and technological literacy.

6.2 Teachers be trained in conducting group practical work, including group assessment.

6.3 Teachers' Guides must be produced to support teaching of science.

C: ORGANIZATION AND MANAGEMENT

(Science Education in Primary and Secondary Schools)

C.1 CREATION OF A PROFESSIONAL ASSOCIATION FOR SCIENCE AND TECHNOLOGY EDUCATORS

A platform for exchanging and sharing of ideas and experiences is required to promote professionalism and networking amongst professional science educators, both within Mauritius and outside. Primary science teachers and Inspectors; secondary and senior secondary science teachers and inspectors, science education and science specialists at the tertiary level will benefit from the hybridization of ideas. A professional association of science and technology educators in Mauritius will be a suitable platform for promoting the quality of science and technology education, professionalism and networking, while putting science education in Mauritius in the international arena. Such an association will

- bring professional science and technology educators within Mauritius together and build a fraternity;
- provide a platform for sharing best practices, research findings both within Mauritius and outside;
- primary, secondary and tertiary level science and technology educators will benefit from hybridization of ideas;
- generate ideas for research in science and technology education;
- promote private- public partnerships in science and technology education;
- promote networking with international science and technology educators; and
- promote professionalism among science and technology educators in Mauritius.

RECOMMENDATION 1:

It is recommended that Mauritius Association of Science and Technology Educators (MASTE) be set up with the support of the MRC to provide a platform for sharing and exchanging ideas, and for international networking.

C.2 COLLABORATION AND COORDINATION

A number of institutions such as MIE, MES, MCA, NCCRD, the University of Mauritius and the University of Technology are associated with the provision of science and technology education in the country. MCA in collaboration with MIE and other partners have produced interesting TV programmes, videos and CD ROMs on different topics of science. There is a need for more such materials because they not

only make science lively and interesting but also bring relevance to the teaching and learning of science. To achieve greater efficiency and quality outputs, there must be greater coordination and cooperation between these institutions. To produce multimedia packages, CD ROMs, TV programmes, audio-visual and assessment materials for primary and secondary education all institutions must work closely while involving experienced classroom teachers.

RECOMMENDATION 2:

It is recommended that MIE, MCA, UoM and UTM should pool their resources and scale up their efforts to produce multimedia packages, CD ROMs, Videos and TV Programmes based on the curriculum for primary and secondary education.

C.3 AWARDS FOR EXCELLENCE

To further promote interest in science and technology education amongst students, mini-projects at the school, zonal and national level should be organised and prizes distributed at all levels at public functions. Private sponsorship for prizes should be explored, including MRC earmarking special funds for such activities.

In the same way school, zonal and national level science and technology exhibitions should be organized, where students could exhibit their completed projects and science/technology models. This exercise would provide lots of ideas for preparing low-cost science equipment. Here again best projects/models may be awarded prizes at public functions. Sponsorship of the private sector, including funding from MRC, should be explored for organizing such events. The Rajiv Gandhi Science Center could play an important role in organizing such events.

RECOMMENDATION 3:

Mini-projects with a high practical orientation on themes of science and technology and science exhibitions should be organized at school, zonal and national level to maintain interest in science and technology and to popularise science and technology at the community level.

C.4 FIELD VISITS

Visits to local places of scientific and technological interest (see Annex 11) help to reinforce the notion and importance of the application of science. Currently, many schools mostly in the primary sector organise trips to various places. However, these visits are perceived to be tedious and cumbersome to organize at the school level. The major constraints identified were the transportation and costs involved. In addition, too many approvals from the various authorities are required such that many teachers are put off and the visits are no longer considered as a priority, to the point of becoming a burden to the school activities.

RECOMMENDATION 4:

4.1 Field visits should be formalized and be part of the teaching of science and technology in both primary and secondary schools.

4.2 A structured programme of visits in support of the science and technology curriculum must be agreed upon for all primary and secondary schools.

4.3 A centralized unit, eventually at the directorate level, should be set up to organise and implement the visits, including the responsibility for the transportation of the pupils.

CONCLUSION

In this report a case has been made for fundamental changes in science education to prepare the youth and the society of Mauritius to meet the challenges of technological advancement and globalization of the market place. The changes suggested are also aimed at arresting the falling interest amongst the youth in learning science in schools. This report while highlighting problems and issues facing science education in schools has made recommendations that address issues centred around *why* to teach science, *what* to teach, *who* should teach and *how* to teach and assess science in schools. Change is a slow process and it has to be carefully managed and supported.

The report also presents a vision of the kind of science education required in Mauritius, which is based on the needs and aspirations of the youth and society as well as the economic and social developmental requirements of Mauritius. Some of the recommendations made can be implemented immediately while others will require some more ground work, for example review of the science curriculum and enforcing compulsory science. However, it is felt that most of the recommendations can be realised over the next two years. A prime requirement to meet this target is the co-operation of all the stakeholders.

Science teachers will play a major role in implementing the changes required to achieve the proposed vision. They will have to be continually supported to implement the change. It is due to this consideration that (a) regular and frequent in-service training programmes (b) creation of a cadre of School Science Inspectors and (c) establishment of Teachers' Centers to break the isolation of science teachers have been proposed.

A policy decision will have to be taken to make science compulsory up to Form V to develop scientific and technological literacy amongst the youth. The aims of science curricula will have to be clearly defined outlining how it will achieve the desired goal. Curriculum revision will be a major undertaking to achieve the short and long-term vision. Greater importance has been attached to group experimental work to develop investigative and problem solving skills and their continuous assessment. This will require upgrading science laboratory facilities where they are lacking and creating laboratory facilities where they do not exist. The integration of practical assessment and of theory will give recognition to the importance of these two components of science.

ACTION PLAN - (2004-2006)

Science Education in Primary Schools

RECOMMENDATION 1:

It is recommended that

1.1 The aim of science teaching at primary level be redefined to include development of scientific and technological literacy (STL).

1.2 The current primary science curriculum be reviewed and revised to incorporate technological aspects with the objective of developing scientific and technological literacy. Consultation with stakeholders will benefit the review.

1.3 Science textbooks must be reviewed from the language point of view and simplified such that the English vocabulary used is as far as possible consistent with the vocabulary expected at that level.

1.4 Personnel associated with curriculum development would benefit from in-service training in designing curriculum and writing textbooks.

Actions Required:

1.1.1 Presentation of the recommendations contained in this report to the Steering Committee and adoption by the Ministry.

1.1.2 Primary school science curriculum team to review

(a) current science curriculum to incorporate technology aspects without overloading the curriculum

(b) review and revise current textbooks to fit the objectives, to incorporate pedagogical approaches to be followed for developing STL and to simplify language as recommended.

1.1.3 Arrange training for curriculum developers and textbooks writers in curriculum development and textbooks writing.

RECOMMENDATION 2:

It is recommended that a child-centered, active learning approach be used in teaching science to develop thinking, reasoning and problem solving skills amongst children.

Actions Required:

2.1.1 Teachers should be trained in child-centered active learning approaches which promote thinking, reasoning and problem solving skills.

RECOMMENDATION 3:

3.1 It is recommended that group practical work should be promoted at the primary level, which could be performed using materials available locally in the environment and at home.

3.2 Immediate steps should be taken to support schools, which have an extra room to set it up as a science room.

3.3 Alternative models of creating additional space for science room, including sponsorship from the private sector must be investigated for schools that do not have a science room.

Actions required:

3.1.1 Support schools, which have a room that could be converted into a science room.

3.1.2 Try out innovative means such as using a refurbished container as a semi permanent/mobile facility for creating additional space for a science room in schools where science room does not exist.

3.1.3 Encourage and introduce innovative mini-projects that require group activity.

RECOMMENDATION 4:

To overcome the difficulty of language in teaching science at the primary level, it is recommended that

4.1 At the beginning of each chapter explanation/definitions of scientific/technical terms be included which teachers should go over first with students before starting the chapter.

4.2 Maternal language or most commonly used or most easily understood language could be used to explain science concepts, but as per the current practice English should continue to be used for all writing work in science.

Actions required:

4.1.1 During the revision of textbooks, include meaning and explanation of all technical terms and difficult words in the chapter at the beginning of the chapter.

4.1.2 Teachers must be encouraged to use maternal language or most commonly used or most easily understood language to explain difficult science concepts.

RECOMMENDATION 5:

It is recommended that specialized teachers to teach science, mathematics and ICT (a natural cluster of subjects) be appointed in primary schools. It is envisaged that one duly qualified teacher would be able to teach all three subjects.

Actions required:

5.1.1 Administrative procedure to create posts of Science, ICT and mathematics (one teacher to teach all three subjects) teachers in primary schools.

RECOMMENDATION 6:

It is recommended that science teaching be allocated a minimum of 5 periods per week with at least one double period a week to enable students and teachers to undertake practical work in science, including hands-on activities and/or viewing science films.

Action required:

6.1.1 School timetable must be reviewed to accommodate 5 periods to science teaching with one double period and three single periods.

RECOMMENDATION 7:

It is recommended that

7.1 A weightage for continuous assessment be added to final examination to calculate final grade/score to be awarded to a student. It is recommended that the final score/grade should be based on 40% weightage to continuous assessment and 60% to final examination.

7.2 For the group practical work the effort of the group must be assessed and grade/marks assigned to the whole group. Each member of the group would receive the same marks/grade as to the whole group.

7.3 A system of moderation be introduced to achieve consistency and fairness in assessment.

7.4 Assessment materials in the form of question bank in science be produced on a national basis, designed to measure progress and achievement against very clearly defined objectives. To achieve consistency in assessment, standards of acceptable responses will have to be clearly defined in the form of marking scheme.

Actions required:

In the implementation of this recommendation the Mauritius Examination Syndicate (MES) will play a major role.

7.1.1 MES to prepare a paper outlining new assessment procedures to include weightage to continuous assessment including group marking. It will also require explanation of the scheme to teachers, head teachers and inspectors at suitable occasions.

7.1.2 MES to organise workshops to develop question banks. These workshops should be organised after the objectives of science education have been defined and curriculum and textbooks developed.

RECOMMENDATION 8:

It is recommended that

8.1 Regular, frequent and quality in-service training programmes be organised for existing primary teachers to develop their confidence in teaching science, and assist them in organising group practical work, including group assessment.

8.2 Teacher' guides and students' workbooks must be produced to support teachers in their efforts to improve the quality of science teaching.

8.3 Primary School Science Inspectors be appointed to supervise, support and promote best practices in science teaching in schools. The qualifications and experience of the Inspectors should be such that they should be able to supervise teaching of science, mathematics and ICT.

Actions required:

8.1.1 To develop (i) in-service training programme materials for teachers which focus on development of scientific and technological literacy, organisation of group practical work and its assessment (ii) a schedule of training such that all teachers receive training in short duration. To train all teachers in a short duration, a group of resource persons may be first trained who could organise training programmes at zonal basis.

8.1.2 Production of Teachers' Guides, student workbooks, and work cards for each standard to support teachers and students in teaching and learning.

8.1.3 To issue an administrative order for creating posts of School Inspectors (science, mathematics and ICT) and making appointments.

Science Education in Secondary School

RECOMMENDATION 1:

It is recommended that

1.1 A policy decision to have compulsory science for all pupils up to Form V. This would imply that in the current system, those pupils choosing only one Pure Science or no science subject at all at Form III, will have to study the compulsory science subject.

1.2 The content and structure of the compulsory science up to Form V should be locally relevant (Mauritianised) and prepare youth to be scientifically and technologically literate.

1.3 The content and structure should also provide a firm basis for those wishing to continue science beyond Form V, a need that could be met by a bridge-science foundation course.

Actions required:

1.1.1 Policy decision to make science a compulsory subject for all those pupils opting for only one or no science subject at Form IV and V

1.1.2 Review of the science curriculum to include locally relevant scientific and technological issues

1.1.3 Review the timetable for secondary schools.

RECOMMENDATION 2:

It is recommended that

2.1 A policy decision be taken to teach compulsory science as one subject comprising three modules - Physics, Chemistry and Biology from Form I – V with a focus on developing scientific and technological literacy.

2.2 The content overload should be reduced to give way to scientific enquiry through practical work.

2.3 Eventually, 'alternative to practical' exam to be banned.

Actions required:

2.1.1 Policy decision that science be taught as one subject comprising of physics module, chemistry module and biology module while maintaining the spiral continuity in content up to Form V, and assessed as science and that the aim of science teaching up to Form V will be development of scientific and technological literacy.

2.1.2 To review and accordingly modify the existing curriculum of Form I, II and III.

2.1.3 To design the compulsory science curriculum for Form IV and V

2.1.4 To abolish 'alternative to practical' exam when compulsory science is introduced.

RECOMMENDATION 3:

3.1 It is recommended that more active learning approaches to science teaching be employed to develop inquisitiveness, reasoning and problem solving skills amongst learners.

3.2 Greater opportunities must be provided for group work, use of multi media packages and computer software, including CD ROMs, to promote independent learning amongst pupils.

Actions required:

3.1.1 Trainers to incorporate active learning strategies to promote thinking, reasoning and problem solving skills during the in-service training of teachers.

3.1.2 Training of teachers to include group learning strategies including use of computers and CD ROMs to enhance learning.

RECOMMENDATION 4:

It is recommended that

4.1 Group practical work should form an essential component of science teaching right from Form I.

4.2 Laboratory facilities be upgraded in those schools where they are lacking.

4.3 Recruitment of qualified laboratory technicians and gradually phasing out the existing post of laboratory assistant.

4.4 Supply and Maintenance of laboratory equipment be decentralized and be managed at the regional level by competent units.

4.5 Alternative models of providing additional space for science laboratories, including sponsorship from the private sector, must be explored in those schools where laboratories do not exist.

4.6 In-service training programmes or other suitable training programes for laboratory assistants must be organised to make them effective resources to complement science teachers.

Actions required:

4.1.1 Support those schools where science laboratories are not up to mark to make them functional.

4.1.2 Try out innovative means such as using a refurbished container as a semi-permanent/mobile structure for additional space for science laboratories in those schools where science laboratories do not exist.

4.1.3 Encourage and introduce innovative mini-projects that require group activity.

4.1.4 Appoint science laboratory technicians in those schools where they do not exist and gradually phase out post of laboratory attendant in all secondary schools

4.1.5 Organise/arrange in-service training for laboratory assistants/ attendants.

4.1.6 Ensure regular maintenance of laboratory equipments by qualified laboratory technicians at the regional directorate level.

RECOMMENDATION 5:

It is recommended that

5.1 The examination for Compulsory Science should consist of both theoretical aspects and practical sessions in each of the three modules, i.e., chemistry, physics and biology on a continuous assessment basis rather than end-of-the year examination.

5.2 For students in Form I, II, III as well as those taking compulsory science in Form IV and Form V, practical work should be assessed by group performance.

5.3 For students in Form IV and V who have opted for two or more pure science subjects (therefore do not undertake compulsory science), practical work should be assessed on an individual basis.

5.4 For students opting for pure science at Form IV and V, an appropriate weightage of the continuous assessment be added to the final examination score for the calculation of final grade/score. It is recommended that the final score/grade could be based on 40% weightage to continuous assessment and 60% to final examination.

5.5 In the continuous assessment of the group practical work, effort of the group must be assessed and grade/marks assigned to the whole group. Each member of the group would receive the same marks/grade as awarded to the whole group.

5.6 A system of moderation be introduced to achieve consistency and fairness in assessment.

5.7 Assessment materials in the form of question bank in science be produced on a national basis, designed to measure progress and achievement against very clearly defined objectives. To achieve consistency in assessment, standards of acceptable responses will have to be clearly defined in the form of marking scheme.

5.8 Assessment panel comprising of group of teachers from different schools to be established by MIE and MES to conduct external reviews and assessment.

Actions required:

In the implementation of this recommendation the Mauritius Examination Syndicate (MES) will play a major role.

5.1.1 MES to prepare guidelines for continuous evaluation for compulsory science and Science subjects including practical sessions.

5.1.2 MES to prepare teacher's guide for group evaluation

5.1.3 Group activities to replace demonstration in lower classes

5.1.4 Guidelines to assess individual practical with a view to abolish 'alternative to practicals' exam

5.1.5 MES to prepare a paper outlining new assessment procedures to include weightage to continuous assessment including group marking. It will also require explanation of the scheme to teachers and Rectors at suitable occasions.

5.1.6 MES to organize workshops to develop question banks. These workshops should be organized after the objectives of science education have been defined and curriculum and textbooks developed.

5.1.7 MES and MIE to create and train the assessment panel to conduct external reviews and assessment.

RECOMMENDATION 6:

It is recommended that

6.1 Regular, frequent and quality in-service training programmes be organized for science teachers to develop their confidence in teaching science for the promotion of scientific and technological literacy.

6.2 Teachers to be trained in conducting group practical work including group assessment.

6.3 Teachers' Guides must be produced to support teaching of science.

Actions required:

6.1.1 To develop (i) in-service training programme materials for teachers which focus on development of scientific and technological literacy, and (ii) a schedule of training such that all teachers receive training in short duration. To train all teachers in short duration, a group of resource persons may be first trained who could organise training programmes at zonal basis.

6.1.2 To organize training programme for teachers in conducting group work and group assessment.

6.1.3 Production of Teachers' Guides by the relevant authorities.

Organisation and Management

RECOMMENDATION 1:

It is recommended that Mauritius Association of Science and Technology Educators (MASTE) be set up with the support of MRC to provide a platform for sharing and exchanging ideas, and for international networking.

Actions required:

1.1.1 Ministry of Education and Scientific Research should constitute, under aegis of the MRC, a committee of stakeholders consisting of primary and secondary science teachers, MIE, MRC, University of Mauritius, University of Technology, Medical School, to develop constitution, aims and objectives, programmes, administrative arrangement and funding mechanism of the Mauritius Association of Science and Technology Educators.

RECOMMENDATION 2:

It is recommended that MIE, MCA, UoM and UTM should pool their resources and scale up their efforts to produce multimedia packages, CD ROMs, Videos and TV Programmes based on the curriculum for primary and secondary education.

Actions required:

2.1.1 Mechanism for greater collaboration between MIE, MCA UoM and UTM must be established so that they could scale up their efforts and produce a large number of multi-media packages, CD ROMs, videos and TV programmes on the science topics in the curriculum to make science interesting and relevant for children.

RECOMMENDATION 3:

Mini-projects with high practical orientation on themes of science and technology and science exhibitions should be organized at school, zonal and national level to maintain interest in science and technology and to popularise science and technology at the community level.

Actions required:

3.1.1 Mechanisms must be set up to facilitate organisation of mini-projects. It will require development of guidelines and identification of theme(s) for mini-projects and funding.

3.1.2 Rajiv Gandhi Science Centre or any other suitable institution may be assigned the responsibility of organising zonal/national mini science projects, drawing guidelines etc.

RECOMMENDATION 4:

4.1 Field visits should be formalized and be part of the teaching of the science in both primary and secondary schools.

4.2 A structured programme of visits in support of the science and technology curriculum must be agreed upon for all primary and secondary schools.

4.3 A centralized unit, eventually at the directorate level, should be set up to organize and implement the visits, including the responsibility for the transportation of the pupils.

Actions required:

4.1.1 Draw a list of locally relevant places of scientific and technological interest (See Annex 11).

4.1.2 Offload the schools with the responsibility of organizing visits by setting up centralized units.