Thematic Working Group

Science & Technology Education

Final Report
July 2001

To

Professor S. Bhoojedhur
Chairman
Mauritius Research Council

This Report is hereby submitted as per our Terms of Reference.

Dr M. Atchia
Chairman
Science & Technology Education Working Group

PREFACE

In the name of the members of the Working Group on Science & Technology Education and in my own name, I wish to thank the Chairman, MRC, Prof. Bhoojedhur, for the trust placed in us to carry out this task.

Meeting on numerous occasions over a period of 3 months (May to June 2001) the Working Group attempted to develop a Research Policy Agenda for Science & Technology Education. It has concentrated on new approach to Science & Technology, appropriate curricula, new active methodology of teaching and learning, links with industry, careers in Science & Technology as well as survey of present capabilities and future needs.

The Working Group as per its Terms of Reference, has identified and described the research needed as background and basis for a Science and Technology revolution to take place in Mauritius.

Thanks are due for the valuable inputs and hard work of the members of the Working Group, to Dr. A. Suddhoo for his support, to Mr. P. Tse Rai Wai for facilitating the meetings, to Mrs. Bina Padaruth and Annick Rayapen for typing the texts.

Dr. Michaël Atchia

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Composition of Working Group

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ABBREVIATIONS AND ACRONYMS USED IN THIS REPORT

"A" Level	*General Certificate of Education, Advanced Level*
"O" Level	*General Certificate of Education, Ordinary Level*
CPE	*Certificate of Primary Education, Mauritius, taken at 11+*
EVS	*Environmental Studies, a subject examinable in Mauritius at CPE Level*
HDI	*Human Development Index (UNDP)*
HSC	*University of Cambridge Higher School Certificate*
ICT	*Information and Communication Technology*
MBC	*Mauritius Broadcasting Corporation*
MCA	*Mauritius College of the Air*
MES	*Mauritius Examinations Syndicate*
MIE	*Mauritius Institute of Education*
MOESR	*Ministry of Education and Scientific Research, Government of Mauritius*
MRC	*Mauritius Research Council*
PSSA	*Private Secondary Schools Authority*
S&TE	*Science and Technology Education*
SBA	*School-based Assessment*
SC	*University of Cambridge School Certificate*
TAI	*Technology Achievement Index (UNDP)*
TEC	*Tertiary Education Commission*
TVET	*Technical and Vocational Education & Training*
UCLES	*University of Cambridge Local Examinations Syndicate*
UoM	*University of Mauritius*
UTM	*University of Technology Mauritius*

All estimated costs are given in Mauritian Rupees (Rs); as at July 2001, 1US$ = 28 Rs.

I THE RELATIVE IMPORTANCE OF THE THEME FOR MAURITIUS

Education is a basic right. It is essential for development, capacity building and active citizenship.

Science and Technology Education (S&TE) is a key element of education. Its direct effect on development and wealth of a country has been well demonstrated.

In the context of the Thematic Working Groups established by the MRC in 2001, S&TE is a crosscutting issue, necessary for capacity building in all other fields from land, marine and water resources through energy and biotechnology to manufacturing technology.

The “sister” theme to S&TE is that of Information and Communications Technology, also a “service” theme.

A basic question was asked: does our school education system, with its syllabuses and method of teaching prepare young people for entry into the world of work, with specific reference to work at middle and higher levels in scientific, industrial and technological fields?

We were concerned about the attitudes and aptitudes of students leaving with an SC or an HSC, their problem identification and problem solving capabilities, their self-learning abilities, their open-mindedness and their level of training in the experimental and rational way of thinking and acting.

As discussed throughout this report, we were concerned about the Mauritian youth of 17-19 years of age and his or her career drive, which, at present, is not strongly oriented towards science and technology. The private and industrial sector must be made full partners in our concern for S&TE.

In brief, the response from the group is that the current situation is not satisfactory and that there is much room for improvement. The output resulting from research into the eighteen topics identified in this report would, we believe, provide a solid basis for improvement in the way in which our educational institutions prepare our young people to become scientifically literate citizens and apt to develop productive careers in science, industry and technology.

II THE CURRENT STATUS OF THE SECTOR: CONSTRAINTS AND CHALLENGES FACING S&TE

The current status of Science and Technology sector in Mauritius is generally felt to be weak as compared to countries like USA, Singapore, Japan and Germany. The fact that we are well in advance of most countries of our region (Africa) is no consolation. The most recent Human Development Report of UNDP (made public in June 2001) highlights the favourable position of Mauritius with regards to its Human Development Index (HDI). Mauritius is placed within the group of Medium Human Development and is ranked 63 worldwide (on a total of 162 countries).

In comparison Singapore ranked 26, Malaysia 56, China 87, South Africa 94, India 115, Kenya 123 while Madagascar (ranked 135) and Mozambique (ranked 159) fall within the Low Human Development Group.

Mauritius also ranks very well for literacy and enrolment, youth literacy, net primary enrolment.

We however fare less well, in comparison to other countries with regards to tertiary students in science, maths and engineering (17% of all tertiary students, 1994-1997) and with regards to a new measurements the Technology Achievement Index (TAI) which measure “the progress of countries in creating and diffusing technology and in building a human skills base”. The index estimates the diffusion of “old innovations” by measuring the number of mainline and cellular telephone, whereas recent innovations are measured by the number of internet hosts per capita: these measurements are not necessarily the best indicators of technology and some more work may be necessary to refine this index. Furthermore it must be noted that the reliability of all UN indices is subject to the reliability of the data **provided by member states**.

The above UNDP report also foresees “the world-class research capacity in some developing countries” as “new sources of technological excellence”. Such research either focus on problems specific to each country or (increasingly) on global issues. In what domain does Mauritius already possess such world-class capacity? Will the implementation of the results of research recommended in this report assist in developing such capacity? What are the main constraints facing Mauritius in the field of Science and Technology for the future?

A brainstorming session amongst Members of this Working Group enabled the identification of the constraints listed below:

- Low level of S&T culture;
- Weakness of a culture of innovation in Mauritius;
- Need for market research for career guidance;
- Insufficient use of the media to popularise science;
- Lack of basic facilities for teaching science in primary classrooms; a
- Undue emphasis in primary science curriculum on memorisation of facts;

- Need to review science curriculum at both primary and secondary levels;
- Lack of scientific background of many primary school teachers who may be teaching primary science;
- Uneven provision or use of science equipment/laboratories in secondary schools;
- An undue emphasis on teaching scientific knowledge to the detriment of scientific skills and attitudes;
- Low take up of science and technology subjects after Form III (particularly amongst girls);
- Perception of many students that science subjects are difficult or not interesting;
- Need for greater importance to be accorded in teaching to applications of science;
- Need for ongoing training for science teachers;
- Lack of school-based continuous assessment and of assessment of competencies;
- Reduction of the amount of practical work done in some schools since the introduction of alternative to practical examinations at SC level;
- Need to review procedures for the assessment of science teaching at both primary and secondary levels;
- Inadequate scientific/ mathematical background of many students who are following IVTB courses;
- Need for a mechanism to coordinate S & T Education;
- Need to identify industrial/commercial needs for the next 10-20 years and formulate S&T educational policy that would suit those needs; and
- Low numbers of women scientists;

The Working Group was informed of the findings of an audit on Science and Technology on Mauritius, carried out in November 2000 by the MRC. This audit was considered to be a pre-requirement towards the development of a national strategic plan for Science and Technology. It went beyond its initial mandate and also examined the capacity of Mauritian firms to innovate. The audit spanned the education, training and the productive sectors, thus giving a broad view of the S&T capacity of Mauritius, with particular emphasis on its strengths and weaknesses. A four-volume report was produced as a result, and a set of recommendations made.

The findings are alarming in so far as science education is concerned. There has been a gradual decline in the popularity of science amongst students in the secondary school sector. Only about 30% of students would sit for science subjects at O-level. With regard to Information Technology, only 10% would opt for this subject at O-level and only 2.3% at A-level. There seems to be two main reasons that one can attribute to this decline; lack of infrastructure and the perception of poor job prospects for those opting for science subjects. Indeed the ‘scientific facilities’ available in many schools across the island leave a lot to be desired; so much so that practical sessions have degenerated into ‘theoretical practical’ with little or no hands on experience. This is also reflected in the practice to assess practical scientific skills through theoretical exams!

At the level of primary schools, scientific education is virtually non-existent. The situation demands drastic reform which should also consider the introduction of IT and experimental science at this level. This reform should also take into account the training needs of teachers as most teachers, particularly at the level of primary, are not scientifically literate and still less IT literate.

III PROPOSED MEASURES TO ENHANCE S&TE IN MAURITIUS

To meet the requirements of providing a solid basis for decision-making in the field of S&TE, a number of research topics have been identified and developed. These are described below.

Appropriate institutes and persons should be contracted to carry out the proposed research. Parallel to this there are a number of support measures that must be taken, for example:

(a) Creating quick and smooth flow of information **from** researchers **to** decision makers (the MRC itself, together with the Ministry for Scientific Research can do this).

(b) Optimising science and technology resources available. In this context a survey of **teaching** and **research institutions**, of **high-level professional research scientists** and **laboratory capacity available is needed**. One should also identify available libraries, museums, exhibition halls, clearing houses etc.

(c) Starting capacity building programmes to improve on areas under (b) above where gaps exist.

(d) In order to promote S&TE, activities and exchanges are proposed amongst science teacher associations and science clubs, together with an exchange programme within the region and world-wide.

Refer to Annex D for a list of regional and international organisations.

The next section (Chapter IV) describes the research which this Working Group has identified as necessary for Mauritius. There are eighteen research topics grouped under three main sub headings:

- **Science, Technology and Society** (7 topics)
- **Science and Technology at school level and beyond: new curricula, new teacher training, learning and assessment methods** (8 topics)
- **Development of Technical and Vocational Education appropriate to the need of Mauritius** (3 topics)

Each research topic is developed according to a flexible format covering such main heading as:

- Objectives
- Background and justification
- Research questions
- Methodology
- Proposed researchers/institutions
- Estimated time frame

- Estimated cost and
- Expected outcomes

Chapter IV represents the main body of this Report.

IV RESEARCH TO BE UNDERTAKEN: NEW RESEARCH AREAS AND PERSPECTIVES IN S&T

Science, Technology and Society

TOPIC 1: Research in S&T Education

Objective:

The objective of the project is to carry out an inventory of the main findings of research on Science and Technology Education, the outcomes of the research and their impact as well as other relevant information necessary to enable us take decision on future research in S & T Education.

Background and justification

Research in S&T Education in Mauritius has been conducted in a rather disorganised way by the concerned institutions. The research reports, unfortunately, are shelved in libraries and these findings have not been properly disseminated. These researches form an important baseline that can be fruitfully tapped as the starting point for more advanced research. A systematic survey of all research completed to date should be initiated and the main findings summarised in a report or at a common website.

Methodology

This study may be carried out through a survey of all the previous researches conducted in S&T Education at the relevant institutions. An analysis of the individual research in terms of the major findings and the recommendations may be effected.

Proposed researchers/Institutions

All libraries/MIE/UoM/MRC/TEC
Science and Technology Education Section of UNESCO (Paris) as correspondent.

Estimated time frame: 6 months

Estimated costs: Rs 200,000 including publications on human and technical resources, IT Facilities, access to libraries; sources of funding.

Expected outcomes

The main findings of key previous research will have been summarised and the results made available in the form of a printed report or on a web-site.

This survey will allow researchers to find out about the areas in S&T Education that have already been researched. It will provide the basic background information to allow researchers to properly organise their research work. It may also reduce the risk of duplication.

TOPIC 2: New Research Areas in S&TE

Objective

Identify areas of S&TE where practically no research is being done in Mauritius and which have an impact on present and future development.

Background and justification

There are certainly many new areas, which need to be addressed. Many are closely related to Information and Communication Technology. These must be identified and thereafter the research and development needed should be defined. Once these areas have been determined, it must be ascertained whether competence is available locally or whether external expertise must be tapped.

Another one of these areas is the treatment and reuse of wastes, others include the attainment of self-sufficiency in renewable energy, in food production and the supply of fresh water.

Integrated Farming Systems such as those developed in China is another aspect, which needs to be developed.

Methodology

(i) Literature survey to list all main science and technology research areas.
(ii) List of those areas currently lacking in Mauritius but which could be of importance for our future development.

Proposed institutions:

(i) Ministry of Environment, Mauritius Research Council, University of Mauritius, Mauritius Sugar Industry Research Institute.
(ii) Science and Technology Education Section of UNESCO (Paris) as correspondent.
(iii) Third World Academy of Science (TWAS) (Trieste) as correspondent.
(iv) UNDP (New York Hq. and/ or local Representative)

Time frame: Six months

Estimated costs: Rs 200 000

Expected Outcomes

(i) New research areas relevant to the needs of Mauritius will be identified.
(ii) It will be possible to choose the methods which are best adapted to our conditions in Mauritius.

TOPIC 3: Science and Society

Objective

The objective of the research is to identify effective means encouraging people at all levels of society to think rationally. This would promote better understanding amongst Mauritians in general.

Background

It is vital for our citizens to be aware of the importance of Science in our daily lives and to be appreciate how the latest research help improve quality of life (e.g. topic such as medicine, nutrition, life expectancy, energy saving, information technology, etc).

From an economic perspective, in the anticipation of globalisation, it is a pre-requisite to sharpen our international competitive edge through harnessing and diffusing scientific information to the general public. This approach should help Mauritius to penetrate new markets and strengthen existing ones, and so open new career opportunities.

Research is needed into ways and means of rendering curricula in science (syllabuses + methods of learning) more relevant to:

- present day needs of Mauritius (example in ICT);
- projected manpower needs of Mauritius in 10, 20, 30 years time;
- the need to make this country a scientifically oriented society.

Methodology

Radical changes in the way science is taught (away from rote memorisation and the ("mug-book" mentality) and towards real experimental science geared to societal needs. As at first step the research will collect and analyse data on the perception of science in the daily life of the average Mauritian.

The second step is to devise a methodology to introduce "science & society" into the teacher formation curricula.

The third step is to popularise science in society and share the results of scientific research with people at all levels of society.

Time frame

An ongoing 5 year project for the popularisation of science and the scientific method.

Estimated Cost

Cost per year: Rs 400,000 including the production of appropriate posters and publications.

Proposed Institutions

Supervisory institution: MRC
Executive institutions
MCA, MBC. UoM, the press and advertising agencies.

Expected results

- Probable benefits would include an improvement in the way people understand science.
- A gradual introduction of the scientific method of rational thinking and experimentation into society and daily life transactions.
- An increase in the number of high level scientists and technologists in Mauritian society.
- New career opportunities.

TOPIC 4: Women in Science

Objective

The objective of this research project is to identify

(i) the major short comings that **deter** women from taking up S&T studies;

(ii) the positive factors which influence girls/women to take up S&T studies;

(iii) the factors which influence girls/women to take S&T as a profession; and

(iv) technical themes as presently available at “O” and “A” levels to girls/women.

(v) The ways and means to sharpen to sharpen the creativity and innovativeness of women and bring them to make a more substantial contribution to development.

Background

Generally, S&T intake at secondary and tertiary level is lower than in traditional or commercial subjects, in spite of EVS being compulsory at primary level. This is more acute in the case of women and more importantly the number of students/girls taking science is at the decline with serious implications for a balanced upliftment of the nation.

The main factors underlying the present state are the shortage of well equipped labs, insufficient teachers, the lack of innovation in teaching methodology, lack of job prospects, the perception that “Science does not pay”, parental influence and narrow industrial structure.

The project may be justified on three grounds:

(i) Economic consolidation;

(ii) An increase in female participation rate in socio-economic development; and

(iii) An transformation of the nation from a low technology to a higher technology situation with higher income and better achievement for women.

Methodology

A first step is to carry out an inventory through a random sample and desk research to obtain an accurate and detailed picture of the situation. For instance, analysis of the data should be used to sensitise teachers to adopt a methodology of science of teaching with a view to appealing to girls (e.g. active experimental method relating to daily life applications). At the same time the research should focus on job prospects both present and future and therefore take as a back drop the industrial and labour market structure.

Other features that can help are public awareness campaigns to promote **women in S&T**, increase awareness of careers opportunity for women in these fields, and disseminate relevant examples/statistics of success stories (especially in male-dominated areas such as engineering, architecture, medicine, etc).

Indicative Cost

Cost of Basic research (2 x 6 man-months + secretarial and I.T. assistance) together with cost of: Public awareness campaigns in schools, colleges, press, radio and TV Rs 500,000.

Time Frame: 1 year

Proposed Institutions

Could be undertaken by the MCA or jointly by MCA + MIE.

Expected results

(i) An appreciation of the causes as to why women don't take up S&T studies;

(ii) Well defined public awareness campaign based on the results of research;

(iii) Development of teaching methodologies to interest more girls on the one hand and entrepreneurs to invest on the other hand; and

(iv) An actual increase in number of girls studying S&T and women taking up Science or Technology as a career.

TOPIC 5: The Choice of science subjects by students

Objectives

To find out the factors that influence the choice of Science and Technology subjects by students and the strategies that may be adopted to make S&TE more acceptable to them.

Background and Justification

It appears that the number of students who opt for Science and Technology subjects at the secondary school level is relatively low and may even be on the decline. It would be quite revealing to find out the reasons for this state of affairs and at the same time the factors that influence students in their choice for S&T subjects. The findings of such surveys may enable the elaboration of appropriate strategies for vulgarising S&TE.

Research Questions

- How many students have taken science subjects at SC and HSC since 1980?
- What factors influence students in their subject choice decisions?
- How much interest do students have for science/technology at different ages?
- What strategies lead to an increase in the number of students choosing scientific/technological subjects?

Methodology

Study of examination entries and percentage pass at SC and HSC level in science and technology subjects from 1980 to date (for Chemistry, Physics, Biology, Geography, Design and Technology, Computer Studies, Food & Nutrition, Human and Social Biology, etc.).

Comparative study of option choices made by students in Forms III and V (considering factors such as gender, rural/urban, mixed schools/single sex-schools, class size, occupation of parents etc.)

Survey of students and parents to identify other factors that are important in subject choices.

Identification of intervention strategies that have been successful in other countries to stimulate interest in science subjects and increase the number of students who opt for these subjects.

Assessment of such intervention strategies in the local context.

Estimated Cost: Rs 250,000

Timeframe: One year

Proposed institution: MIE / MES

Expected outcomes

A better understanding of the factors that influence students to take up or abandon science and technology subjects.

Materials and/or methods which will stimulate interest for scientific subjects and an increased number of students taking these subjects in the future.

TOPIC 6: Children's understanding of Scientific and Technological Concepts

Objectives:

To find out how children understand basic scientific and technological concepts.

Background and Justification

Research work conducted elsewhere on this topic has influenced teaching methods used in science and technology education. Similar research carried out in Mauritius may reveal the need for change in the way science and technology is taught in our schools. It may also reveal other factors that influence the understanding of science and technology.

Research Questions

- What do students understand by certain scientific and technological concepts and terms?
- How does the understanding of scientific concepts/terms by our students compare with that of students in other countries?
- What are the factors that influence our students' understanding in science and technology?
- What are the problems encountered by students in understanding S&T concepts and terms.
- How do exams/teaching methods/text books/practicals influence understanding of S&T.

Methodology

- Survey of literature on this area.
- Interviews with individual students to probe their understanding and comprehension of scientific and technological terms and concepts. S&T teachers could be involved in this process.
- Classroom observations to identify problems that students have in understanding science and technology concept.
- Comparison with results obtained in similar studies in other countries.

Proposed Institutions:

MIE, UOM, UTM, MOESR, PSSA with the possible participation of an organization that has carried out such research elsewhere and the collaboration of state, private and confessional schools..

Estimated Cost: Rs 500,000

Proposed timeframe: 1 year (with a possible extension by 6 months, if it is found that the results in Mauritius are dissimilar to those in other countries).

Expected Outcome:

A better comprehension of children's understanding of Scientific and Technological concepts, leading to improved S&TE.

TOPIC 7: Market Research

Objective

The objective is to determine what are the various areas/spheres where science and/or technology is needed.

Background and justification

It is a fact that the average Mauritian student does not know whether information on job prospects is available and where.

This year about two hundred young persons will come out of the University with a degree in Agriculture. However, it seems that only a few will manage to secure employment related to their degree. This would not have happened if these new degree holders had been aware of the job availability in that sector before starting their university studies.

The big craze of the moment is IT. Little information is available on how many people need to be trained in IT itself or in the technical aspect, i.e. maintenance and repairs. We might end, like for agriculture, with too many people knowing how to use a computer and too few knowledgeable in the technical aspect. There is a big difference between someone who is computer literate, and another who is a specialist in IT.

Methodology

The proposed methodology will include:

(i) a survey of all domains exploiting S&T
(ii) an inventory of similar studies on career guidance carried out elsewhere
(iii) forecasting needs in S&T on the basis of current developments and trends (both local and international)
(iv) a plan to build up this research as a regular feature.

Proposed Institutions

Central Statistical Office, Ministry of Education and Scientific Research, Mauritius Chamber of Commerce and Industry, Ministry of Economic Planning, Development, and Human Resources, UoM, MRC (to contract out).

Time frame: 9 months

Estimates costs: Rs 300,000

Expected Outcomes

This study will guide young people as to whether they should go for science and/or technology and in what areas, in the light of job prospects.

A series of websites carrying career data targeted at students. As a result there will be better human resources planning in this country.

Science and Technology at school level and beyond: new curricula, teacher training, learning and assessment methods

TOPIC 8: Introducing Futuristic Science in Schools

Objective

The aim of this project is to prepare primary and secondary school students to face developments in frontier science in the next ten to fifteen years.

Background and Justification

Elementary school science is presently introduced through environmental studies and basic science courses in the classical science subjects of Mathematics, Biology, Chemistry and Physics. By the time the students come out of school in the next ten to fifteen years, the frontiers of science will have been pushed much further. There is need therefore for students to start appreciating fundamentals of these developments if they are to take up scientific and engineering careers. Already subjects like the human genome, biogenetic engineering, biotechnology, robotics, bio-feedback science, nano-technology, space science/technology, e-medicine, and a host of other topics are making their appearance in popular publications. The barriers between physiology, psychology and medicine are fast shedding, and parapsychology is finding its place in accepted science. It is hence necessary to introduce some elements of these frontier sciences in our school curricula, and prepare teachers to familiarize their students with these developments. This will make the learning of science much more interesting and attract more students to take up scientific and engineering careers.

Methodology

The methodology consists in organizing a series of workshops for teachers of both primary and secondary schools. After introducing these frontier sciences to teachers appropriate curricula for students should be developed. Teaching material with necessary teaching aids and audio-visuals, video-films, etc. can be developed with the cooperation of the MIE and the MCA.

Estimated Cost: Rs 300,000

This sum of money will be required to organize a series of six workshops with the assistance of resource persons from the Mauritius Institute of Education, the University of Mauritius and other partners to develop the necessary curricula and teaching aids for the courses.

Time Frame: One academic year.

Proposed Institutions

University of Mauritius, MIE and MCA

Expected results

The main expected outcomes are summarised below:

- Frontier sciences popularised.
- Curricula ready, along with teaching aids, and teaching materials.
- Teachers trained to conduct classes in elements of frontier sciences.
- Students motivated to take science and engineering subjects.
- Public to be kept abreast of the latest developments in S&T areas.

TOPIC 9: Developing relevant and innovative Science and Technology Curricula for eleven-year schooling

Objective

To assess the suitability of the existing S&T curricula in the context of curricula 11-year schooling and prepare new ones.

Background and Justification

In the primary school programme there is no separate science curriculum. A few science components are encapsulated within an Environmental Studies (EVS) syllabus which is being taught by teachers, many of whom have not studied science at secondary school level. Facilities for teaching S&T such as science demonstration rooms or science kits do not exist.

For lower secondary, the science curriculum being used, was prepared some twenty years ago and contain little technology.

For the development of the science curricula referred to above there has been little research.

Research Questions

(i) What are the strength and weaknesses of the existing S&T curriculum.
(ii) What are the knowledge, attitude and skills needed by students on completion of 11 years of schooling.
(iii) Is the present assessment system appropriate for S&T Education.

Methodology

(i) Carry out an indepth SWOT analysis of the present S&T curriculum.
(ii) A comparative study of S&T curriculum in Mauritius and other countries e.g. Singapore, Australia, U.K., Kenya, Hong Kong
(iii) Survey of opinions of employers, educators, parents, students.

Proposed Institutions

MOESR/MIE/State, Private and Confessional schools

Estimated Timeframe: 6-9 months

Estimated Cost: Rs 1 million

Expected Outcome

- Recommendations for more relevant and interesting S&T curricula for the proposed 11 year schooling which will equip school leavers with an adequate science and technology background and enable them to respond better to the emerging needs of a technology dominated environment of the future.

TOPIC 10: School-based Assessment in S&T Education

Objective

To find out whether SBA is a more appropriate method of evaluation in S&T Education.

Background and justification

Many countries have now chosen school-based assessment as one of the evaluation methods in Science and Technology Education. However recent attempts to extend this in Mauritius have not been successful. Further studies on SBA in the Mauritian context may lead to a better understanding of the benefits of SBA and of the measures necessary for its implementation.

Students projects, for example during the 2 years of studies at HSC level can best be monitored and assessed at school level.

Research Questions

1. To what extent is SBA currently being used in S&T Education in schools?
2. What are the forms in which SBA is used in S&T Education?
3. What are the strengths and weaknesses of SBA in S&T Education in our schools?
4. How is SBA perceived by the different stakeholders?
5. What are the necessary conditions for the successful implementation of SBA?
6. Which other forms of SBA may successfully be used in S&T Education?

Methodology

- Survey of the way Science & Technology is currently being assessed in schools.
- Analysis of effectiveness of existing SBA in S&T Education.
- Survey of opinions of students, parents, teachers, etc.
- Document analysis on the use of SBA in S&T in other countries.
- Propose where and how SBA is to be introduced into our assessment procedures at CPE, SC and HSC levels.

Proposed Institutions

MES, MOESR, MIE, PSSA

Estimated Time Frame: 6-9 months

Estimated Cost: Rs 500,000

Expected Outcomes

This study may provide valuable information concerning the need for extending SBA, the appropriate form of SBA and the framework necessary for it to be successfully implemented.

TOPIC 11: The current status of Technology Education in our schools

Objectives

To find out how and to what extent is technology being taught in our schools.

Background and justification

Technology education is present in our school programmes as a component of several disciplines namely EVS at the primary school level and Agriculture, Design and Technology, Food and Nutrition, Fashion and Fabrics, I.T. etc. at the secondary level. These disciplines have been introduced in the school curriculum over the years in response to the changing needs associated with the growing importance of technology in all spheres of life. The approach has been to go for disciplines that are directly relevant to the economy based on Agriculture and industries. However, not much is known about the relevance and impact of these disciplines in the improvement of Technology Education in our schools. This study will reveal the roles played by the different disciplines in uplifting technology education and the extent to which this is taking place. There is no doubt that Technology Education should be consolidated in our education system to prepare the next generation of school leavers to adapt to the highly technological society of tomorrow.

Research Questions

- What are the curricular disciplines (subjects) which at present include technology education?
- What are the objectives of each of these disciplines?
- How are these disciplines taught at present?
- Are schools properly equipped for the teaching of technology?
- Do teachers have adequate training for teaching technology?
- Are the syllabuses relevant to the future needs of the students?
- Are the syllabuses relevant to the future technological needs of the country?
- How is technology education linked with the world of work?
- How is technology education evaluated in schools?
- What is the general perception of students, parents etc. with regard to technology education?

Methodology

This study will be based on curriculum analysis and evaluation in schools and on a survey conducted to collect the opinion of all the stakeholders associated directly and indirectly with Technology Education. It may comprise:

1. A general survey of all the disciplines linked with Technology Education that are taught in schools.
2. An analysis of the content and the methods of teaching of the curriculum for each discipline.
3. An analysis of the impact of each discipline with regard to Technology Education.
4. A survey of the opinion of curriculum developers, educationists, employers etc. on the issue.

Proposed Researchers/Institutions

1. A team comprising scientists, technologists, educators, economists, etc.
2. MOESR/MIE/UoM/UTM/PSSA/IVTB

Estimated time frame: 6 months

Estimated cost: Rs 500,000

Expected outcomes

This research will shed light on the status of Technology Education and of its impact on our education system. It will enable decision makers to take informed policy decisions with regard to Technology Education in the future.

TOPIC 12: How to provide an on-going effective and efficient training for teachers for Science and Technology?

Objective

To develop strategies towards the provision of flexible means of teacher training on an on-going basis for S&T Education.

Background and Justification

One of the factors that affects the quality of teaching and learning is the training of teachers. From previous discussions and observations, it appears that many of our Science and Technology teachers do not have sufficient knowledge and skills to teach effectively. This is true both in primary and secondary schools. At primary school level many components of the Science Curriculum are taught by teachers who themselves do not have the knowledge and the skills. Very often they have not studied Science at ‘O’ level. At secondary level young graduates fresh from University are recruited as teachers. They have at times to wait for 10-15 years before they can register for the PGCE. There is no opportunity for the regular update of knowledge and skills that is so important for teachers.

There are in Mauritius approximately 1000 Science and Technology teachers at secondary level. At primary level there are about 3500 general-purpose teachers who by and large do not teach Science and Technology. Quality of teaching and learning of Science and Technology often suffers on account of insufficient teacher training.

There is an urgent need to explore alternative means of teacher training. Information and communication technologies offer tremendous opportunities to provide for “just-in-time training”. Open and distance learning methods enhanced by ICT can be a preferred method both for employers and the teachers on account of the inherent flexibility of these methods. Once teachers are exposed to these opportunities, they will find it easier to apply ICT in their teaching.

Research Questions

1. Do science and technology teachers have the relevant knowledge and skills to teach S&T efficiency effectively?

2. Do S&T teachers have the opportunity for regular in service training?

3. What is the quality of S&T teaching in schools?

4. Are there alternative means of S&T teacher training?

Methodology

Conduct a survey to collect information regarding the
- current ways of teaching Science and Technology
- qualification/experience of teachers of S&T
- gaps in the knowledge and skills of S&T teachers
- constraints that hinder provision of relevant training
- resources and support available to teachers
- training needs of teachers
- preferred means of training from teachers’ viewpoint.

Proposed Institutions

MOESR, MIE, MCA

Estimated time frame: 6 months

Estimated Cost: Rs 150,000

Expected outcomes

Information collected will identify gaps and deficiencies in the training of S&T teachers and will help to develop more effective and efficient teacher training strategies.

TOPIC 13: How can multimedia be integrated into instructional materials to enhance teaching and learning of Science and Technology?

Objective

To improve the quality of instructional materials, by rendering them more interactive, so that they promote active learning and illustrate the immediate relevance of Science and Technology to our everyday life.

Background and Justification

At present the instructional materials used in Science and Technology are heavily based on printed materials. Rote learning is often a favoured means of learning. This often results in students failing to see the real application of the different aspects of Science. Many students often cannot apply scientific theory/principles. Rapid advances in development of multimedia and Information and Communication Technologies offer tremendous opportunities towards integrating multimedia in instructional materials. These materials can make the teaching and learning of Science and Technology more interesting and can help to promote active learning. It can also respond to different learning styles and promote creativity.

Methodology

- Review the instructional materials used by students of Science and Technology with a view to identify their strengths and weaknesses.
- Conduct a survey to collect information regarding:
  - ways of teaching/learning Science and Technology;
  - possible ways of rendering the teaching and learning of Science and Technology more interactive and more meaningful;
  - possible constraints that hinder integration of multimedia materials;
- Analyse the information and recommend the best ways to integrate multimedia in instructional materials.

Proposed Institutions

- Mauritius College of the Air
- Mauritius Institute of Education
- Mauritius Broadcasting Corporation
- Media specialists

Resource requirements and estimated costs

One Research Assistant and one Multimedia Specialist to be hired for 6 months –
Rs 200 000.

Time frame: 6 – 8 months

Expected outcomes

A better understanding of how multimedia can assist in improving science teaching. An improved version of study materials, which are more learner-centred, interactive and which promote active learning.

TOPIC 14: The teaching and learning of S&T in schools

Objective

To identify how S&T is currently taught and learned in schools and find out ways in which teaching and learning in this area could be improved.

Background and justification

At the secondary school level science is taught as the pure sciences (chemistry, physics, biology) and as applied sciences (agriculture, food and nutrition, design and technology etc.). However, no systematic study has been carried out to find out:

(i) the way S&T is taught in the classroom
(ii) the way S&T teachers perceive their roles
(iii) the impact of S&T teaching on students knowledge, attitudes and skills
(iv) the resources available in schools for the teaching of S&T
(v) the way S&T education is evaluated and assessed
(vi) students' appreciation of the subject.

Research Questions

- What are the objectives of S&T education in schools?
- How do S&T teachers perceive their roles?
- What are the perceptions and expectations of students studying S&T?
- What are the resources, time allocation and facilities available in schools for the teaching of S&T?
- What are the methods/strategies used by teachers to teach S&T?
- How is S&T education assessed in schools?
- How to make the teaching and learning of S&T more interesting for pupils?

Methodology

This study could be carried out through:

(i) a survey using both questionnaires and interviews with representative samples of teachers with regard to their perception of their roles as science teachers.
(ii) a survey using both questionnaires and interviews with representative samples of pupils from schools (both primary and secondary) with regard to their expectation and appreciation of science.
(iii) observations of how science is currently taught in selected classroom.
(iv) a survey of the resources and facilities available in schools for the teaching/learning of S&T.

Proposed institutions

(i) a multidisciplinary team of experienced educationists/curriculum developers/teacher trainers/evaluators from MIE,UOM,UTM,MOESR,PSSA,BEC
(ii) Collaboration of heads and teachers of State, Private and Confessional secondary schools.

Estimated time frame: 6-8 months

Estimated cost: Rs 500,000

Expected outcomes

The findings of the research will help to identify shortcomings in the teaching of S&T and will enable decision makers to devise new policies and approaches to improve the teaching of S&T in schools.

TOPIC 15: S&T curriculum review and renewal in schools

Objective

To assess the relevance and appropriateness of the present science and technology curriculum used in schools and the need for its review and renewal.

Background and justification

The present S&T curriculum has been used in schools for a number of years. It has been prepared by a panel of curriculum developers who have relied largely on their intuition to get the right balance in the curriculum in terms of the relevance of the content, the teaching/learning strategies and the evaluation. The curriculum is reviewed at regular intervals but only minor changes are made following limited feedback obtained from teachers. These changes do not really address the following basic issues:

1. how to make the S&T curriculum less academic and more functional?
2. how to make the S&T curriculum more interesting and attractive for students?
3. how to make the S&T curriculum more relevant to the needs of students and of the country?

Research Questions

How is the S&T curriculum designed and planned?
How is the S&T curriculum implemented in schools?
How appropriate is the S&T curriculum in schools?
How is the S&T curriculum assessed in schools?
How is the S&T curriculum reviewed and how often?
What are the strength and weaknesses of the S&T curriculum?
How could the S&T curriculum be improved?

Methodology

This study warrants a series of document analysis, case studies and surveys as follows:
1. a close and critical analysis of the present curriculum in terms of its design, planning and implementation.
2. a survey of opinion of the major stakeholders including students, teachers, school administrators, parents, employers, curriculum developers, etc.
3. case studies of selected schools to obtain more in-depth information about the actual problems in schools.
4. A comparative study of the S&T curriculum from some other countries.

Proposed institutions

1. A multidisciplinary team of experienced curriculum developers
2. MOESR, MIE, MES, PSSA, UOM, UTM

Estimated time frame: 6-9 months

Estimated cost: Rs 500,000

Expected outcomes

This research is an essential first step in developing a S&T curriculum which is both suited to student needs and the needs of the country.

Development of Technical & Vocational Education appropriate to the needs of Mauritius

TOPIC 16: Technology in Vocational Training (Methodology of Learning and Teaching)

Objective:

(i) To identify how "Technology" is taught in Technical and Vocational Training Institutions.

(ii) To propose measures to improve the effectiveness of teaching "Technology" in Technical and Vocational Training Institutions.

(iii) To assess the contribution of ICT in the effective teaching of "Technology".

Background and Justification

Teaching of Vocational /Technical subjects, such as Electrical Installation, Motor Vehicle Mechanics, Air Conditioning and Refrigeration, Agriculture, Design and Technology etc. involve the transfer of knowledge of Technology (Applied Science) to students / trainees. These students / trainees develop practical skills and acquire theoretical knowledge during their training.

Teaching of the practical component involves project work, whilst teaching of theory is performed mostly through "chalk and talk". Being given the high investment cost in technical education and training, and that a good foundation is required for the student/ trainee to cope with the rapid development in Technology, it is imperative that alternative modes of teaching the theory component of the subject be implemented. This is in order to produce higher calibre students/trainees, who will be capable of understanding the scientific principles behind the various skills that they are acquiring. It is only then that they will be able to carry out "fault finding" and solve problems efficiently and effectively.

Methodology

It is expected that the selected research team will: -

(i) carry out a survey of the various teaching techniques used in Technical and Vocational Training institutions;

(ii) identify the various pedagogical techniques used around the world;

(iii) evaluate these techniques and propose the best practices that can be implemented in the local context.

Proposed Institutions

(i) Mauritius Institute of Education
(ii) I.V.T.B.
(iii) Relevant foreign Institutions.

Estimated Time Frame:

Six months

Estimated Costs

Rs 300,000.

Expected Outcomes

It is expected that the proposals to be made following the research will provide appropriate pedagogical techniques for the teaching of Technology in Technical and Vocational Training institutions. These proposed measures will be implemented in existing Institutions, and evaluated at the end of a set period.

TOPIC 17: Technacy

"Technacy is the technological equivalent to Literacy and Numeracy. It is defined as competence in S & T problem-solving that develops the ability to integrate the human, social, environmental and technical aspects of technological issues or initiatives".

Research Objectives

(i) To identify the present situation with regard to Technacy in the existing curriculum.

(ii) To propose measures to increase Technacy amongst various groups such as young children, their parents and the community at large.

Background & Justification

S & T education needs to be better integrated in the curriculum at all levels as a skill for living. The education system needs to encourage the development of analytical skills so that as new issue arises people are able to deal with it sensibly. The skills of judgement and discretion in selecting information should encourage curiosity and learning rather than just passing examinations.

Mauritian Industry requires people with a better understanding of S & T leading to a labour force with more adaptable skills and the flexibility to deal with on-going rapid technological change. An S & T literate community is essential for investment in new and technologically high value added industries.

We need an S & T literacy (or Technacy) that will allow us to:

- use S & T effectively in decision-making process;
- discuss and adapt new S & T developments;
- appreciate Science as part of our culture;
- maximise the benefits of S & T in our daily lives and;
- build strong S & T Systems and expertise, including an educated workforce.

Methodology

It is expected that the Research Team will : -

(i) carry out surveys to assess the present level of Technacy of our students;

(ii) study practices in other countries and define strategies that will enhance Technacy in our education system and;

(iii) propose measures for embedding Science and Technology in Mauritian Culture.

Proposed Institutions

(i) University of Mauritius
(ii) Mauritius Institute of Education
(iii) I.V.T.B.
(iv) Science and Technology Education Section of UNESCO (Paris) as correspondent
(v) Reputed Science Institutes outside Mauritius

Estimated Time Frame

3-6 man-month

Estimated Cost

Rs 200 000

Expected Outcomes:

It is expected that the results of the research would be

(i) used by the Ministry of Education & Science for the review of curricula in order to enhance Technacy.

(ii) Used by various organisations such as MCA, MBC TV and other media organisation in order to propagate the Technacy in the community.

TOPIC 18: S&T for Technical & Vocational Education and Training

Objectives

(i) To assess the S & T profile of students joining TVET and propose measures for its improvement.
(ii) To identify the ideal S & T profile of students who would eventually be trained as technicians to satisfy the manpower needs of the country.
(iii) To propose mechanisms for incorporating industry's needs in basic science in their technical workforce.

Background and Justification

TVET helps to "produce" the workforce of to-morrow. This workforce will operate in an environment that is in constant mutation. In order to survive, this workforce will have to be flexible, possess a wide range of skills and competencies, be able to diagnose and solve problems. This workforce will be able to thrive if its S & T base is firm and it has been groomed to be "curious".

Investment in TVET is expensive, hence it is essential to optimise both its input and output. It is imperative to ensure that the output of TVET satisfy the needs of the Industry, whilst at the same time ensuring that the input into the TVET system possess the relevant S & T competencies.

Methodology

It is expected that the Research team will:

(i) Survey the students population in Vocational & Technical institutions in the country.
(ii) Organise brainstorming sessions with stakeholders
(iii) Study "experience from other countries"
(iv) Determine the necessary science basis for all technical and vocational training

Proposed Institutions: (i) M.I.E
(ii) I.V.T.B

Estimated Time Frame: 2-3 man month

Estimated Cost : Rs 100,000.

Infrastructure *:* Nil

Expected Outcomes:

(i) Science profile of existing students in TVET.
(ii) Ideal Science profile of students joining TVET.
(iii) How to incorporate industry needs in basic science and technology in their technical workforce.
(iv) How to make all TVET students literate in science.

V CONCLUDING REMARKS

1. Educational Policies and Practices

1.1 The Mauritian Context

The aim of this Report is to identify ways and means of developing Mauritius into a country with a higher proportion of productive scientists and technologists, all of whom would be cyber competent.

How to do this in practice? The short answer is through **Science Education**. In order to understand clearly what this means, it is necessary to define our terms.

What is education? In a new (2001) UNESCO encyclopaedia on Natural Resources, Atchia defines education as: "**a process of transmission from one generation to the next of acquired knowledge, concepts and skills, a process which leads to the personal development of the learner".**

What is Science? It is a systematic way of thinking and problem solving that can be used by all of us, not only by people with white coats in laboratories. Science as a stepwise process of thinking involves (amongst other things) **observation**, **investigation** and **interpretation**.

In "Science, Technology and Society" (1992), D. Andrews describes **the process of science** as follows:

1. On previous mornings you have made observations about the type of clouds in the sky and during the day you have registered whether or not it rains. Accurate observations and measurements form the basis of the scientific approach.

2. On the basis of these observations you develop your own 'theory' about rain clouds. Like a scientist, you express your theory as a generalisation that explains the link between the colour of the clouds and the risk of rainfall: dark clouds are usually linked with rain.

3. You use your theory to make predictions about the future and to help you make decisions. You decide to take your umbrella if there are dark clouds in the sky.

4. A thoughtful scientist will always be on the lookout for observations that might question the truth of a particular theory. These anomalous observations can lead to the rejection of an old theory and trigger the search for a new one. Your rain cloud theory will be undermined if a dark, cloudy sky does not produce rain. You will modify or completely discard your theory, just as scientists do, if new evidence comes to light.

Science education aims at the general acquisition by young Mauritians, from an early age, of high level of skills in

- OBSERVING, problem identification and discovery
- PLANNING & INVESTIGATION, the experimental phase
- INTERPRETING, and analysis of data
- HYPOTHESISING and innovation
- APPLYING (applied science and technology for problem-solving and concrete innovation)

These skills are essential life-skills, the general acquisition of which can seriously promote the development of a country.

1.2 Policy

The scientific and technological aspects of the present rounds of reform by the Ministry of Education are not clearly spelt out as yet. Clear policy guidelines on S&T Education are urgently needed at **all** levels of the educational system. Such policy on S&T Education can still be incorporated into the reform process since the reform transition period as proposed is fairly long (2002-2006).

1.3 Levels

It is quite clear that a successful industrialised country has competent people at all levels of industry, from a first level of apprentices and maintenance staff through middle level technicians to top level professional scientists, technologists, economists, planners, architects, engineers and managers. Such are the needs of industry. And so indeed are abilities distributed in a given population.

Levels of qualifications could be broadly listed as follows, with the assumption that in a modern, open-ended society, those who wish and have the ability to do so can acquire additional training and move up the ladder:

- National Technical Certificates
- “O” Level
- “A” Level in scientific and technical aspect
- HSC + 1 Certificate
- HSC + 2 Diploma (BTS)
- HSC + 3,4,5 Degree, Professional qualifications
- Higher Degrees M.Sc., M.Phil, Ph.D.

1.4 Other related competencies

Increasingly scientists and technologists are either required to have **other competencies** or are to work in teams where these competencies are available.

Be it as it may, the training of scientists and technologists ought to include, in future, the following competencies:

- **ICT skills**
- **Law and Politics**
- **Economics, Finance and Marketing**
- **Human and Resource Management**
- **Environmental and Citizenship Education**

2. Research Policy Agenda

An urgent need was strongly felt for the development of a **Research Policy Agenda** for Science & Technology Education for Mauritius. The main steps in developing such an Agenda (as applied for example by WHO for the "Health for All" objective) are as follows:

- **review** problems of critical significance to achieving good Science & Technology education;

- **suggest** ways of harnessing the power of Science & Technology;

- **highlight** a number of research "imperatives" and "opportunities";

- **refrain** from providing an ordered list of "research priorities" since priorities depend on "for whom they are established"; each national government has its own political priorities (such as cyber development for Mauritius in 2001-2005), donors and institutions having also their priorities (depending on their mandates, resources and capabilities);

- **develop and implement** the research proposal with the assistance of individuals and organisations, while facilitating the networking of the entire research community engaged in research (co-ordinated for example by a national research council or by a university);

- **include** in the Research Policy Agenda considerations of the ethical, cultural and value systems of the country, which will facilitate the integration of the results of research into the **decision-making process,** this being the final objective of such an Agenda.

3. Recommendations

3.1 The absolute and urgent recommendation of this Working Group is for **a vast upgrading in quality, quantity and diversity of science and technology education in Mauritius.**

3.2 Meeting over a period of 3 months (May-July 2001), the Working Group has attempted to develop a Research Policy Agenda for Science & Technology education. It has concentrated on research related to

approach to science & technology, appropriate curricula, new active methodology of teaching and learning, links with industry, careers in science & technology as well as survey of present capabilities and future needs.

The Working Group as per its Terms of Reference, has identified and described the research needed as background and basis for a Science and Technology revolution to take place in Mauritius. **Priority must be accorded to funding and implementation of these recommended research projects**.

3.3 Yearly monitoring of international indices and indicators (such as the HDI and the TAI of UNDP and the comparative statistical data from UNESCO on science and technology education) is recommended as a means of assessing our country's progress and its inter-national competitivity.

3.4 Decision-makers at Ministerial, para-statal and private-sector levels must make it a priority to consult the top level scientists and technologists of this country **prior to** (in particular) long-term planning decisions on, for example, transport, environment, education and formation, health, production and development. At present, consultations by Government is often limited to local businessmen and industrialists, cultural and religious bodies, employers and trade union leaders, together with a spate of foreign consultants.

3.5 The need to closely monitor the implementation of the proposed research is strongly felt. It is therefore proposed that this Working Group would (if its members are willing and MRC approves) remain as a standing body for the next 2 to 4 years. The Working Group would then meet occasionally on an ad hoc basis (e.g. every term or semester) for the purpose of assessing the progress of the research and advising on re-orientation where need be.

Annex A: Original List of Research that could be undertaken, as identified by the Working Group

Theme 1: Primary Education

- The cause of failure at CPE level.
- Enquiry into the performance in society of failures, 3, 8, 13 years after.
- Enquiry into the comparative performance of 4A students in later life.

Theme 2: Secondary Education

- Causes of success
- Factors (such as address, family income, size of residence, type of school etc.) which contributed to achieving aggregate of less than 10 at SC, i.e. the most brilliant students.

Theme 3: Replication of research in education as carried out elsewhere for determining

- How Mauritian children learn;
- The link between home & school in relation to effective learning; and
- Why are children at risk and how do they learn eventually to cope with life.

Theme 4: Sustainable Development Education

Research into content and method of **Sustainable Development Education** appropriate to the environment and development needs of Mauritius. The results of this Research could be presented as part of the Mauritius input into the “Rio+10” UN Conference on Sustainable Development in Johannesburg in September 2002.

Theme 5: Women in science

- How do Women make a difference in Science and Technology?
- What are the positive factors which influence girls/women to take up
  - Science & technology studies?
  - Science or technology as a profession?

Theme 6: Science and Society

- Research to identify effective means of introducing the scientific methods of rational thinking and experimentation into society.
- The aim is to make this country a scientifically oriented society.

Theme 7: Providing Mauritius with the critical mass of skilled scientists & technologists for development

- Quantitative research to count numbers of scientists and technologists by age group and area of expertise:
  - Presently available;
  - In training; and

- To make possible projections for the future.

Theme 8: Development of Science Curricula

- Strengths and weaknesses of the syllabii/curricula being utilized in primary and secondary schools.
- Objectives and contents of the science syllabii/curricula for primary and secondary schools relevant to the future needs of the country.
- Utilization of IT in the teaching of Science.

Theme 9: Impact of IT on the future of school Science Laboratories

- SWOT analysis of the interfacing/complementing science practicals with interactive computer simulations.
- Structure and requirements for new Science Laboratories in schools.

Theme 10: Study on students taking the sciences in secondary schools

- The number of students taking science subjects in Forms V and VI since 1980 in private, confessional and state schools.
- Analysis of the data collected, observations thereon and reasons for the trends noted.
- Recommendations on future course of action in the anticipation of globalisation.

Theme 11: Training of teachers

- What is the current situation with respect to training of:
  primary school teachers of EVS, secondary school teachers of science, for form I to III, Form IV and V, Form VI.
- How effective are current teacher training programmes?
- What are the most cost-effective methods of training teachers?

Theme 12: Resources

- What resources are currently used in science teaching? How are these resources used?
- What available resources (local or otherwise) are currently under-exploited?
- What are the resource needs of various sectors of science education?
- How effective are resources produced or available at the MCA, the MIE?
- What support structures would be beneficial to teachers?

Theme 13: Take up of science subjects by students

- What factors influence students in their subject choice decisions?
- Comparative study of option choices made by students (considering factors such as gender, rural/urban, mixed schools/single sex schools, class size, interest for science at different ages)
- Identification of strategies to increase take–up of science subjects.
- Which are the most popular subjects at SC and HSC levels and why?

  – Maths and Physics

- Chemistry and Physics
- Biological Sciences
- Technical subjects such as design, nutrition, fabrics, etc.

Theme 14: Science teaching

- What teaching methods are used in Mauritius to teach science?
- How effective are different teaching strategies – in stimulating interest in science, and for understanding?
- How can technology be successfully integrated into the science classroom?
- How can 'best practice' be disseminated?

Theme 15: Curriculum materials

- An assessment of the suitability of MIE/NCCRD texts – a comparative study of these schemes with those used in other countries e.g. Singapore, UK, Australia, Hong Kong, Kenya.

Theme 16: Children's understanding of science

- What do students understand by certain scientific concepts or terms?
- How does the understanding of scientific concepts/terms by our students compare with that of students in other countries?
- How does language competency affect the Mauritian student's understanding of science?

Theme 17: Technacy in Primary and Secondary School Curriculum

- What is the present situation with regard to Technacy in the existing Curriculum?
- What are the benefits of including Technacy in the curriculum?
- What are the barriers to its inclusion?
- What are the implications?

*(**Technacy** is the technological equivalent of Literacy and Numeracy)*

Theme 18: Creativity and Innovation in S &T Education

- What is the present situation with regard to Innovation and Creativity in Mauritius in S & T education at Pre-primary, Primary, Secondary and Tertiary level?
- What can be done to promote and develop creativity and innovative skills in our students?
- What are the expected benefits of Creativity and Innovation in S & T education?

Theme 19: Role of Media in the Promotion of S &T

- How can media help in the promotion of S &T education?
- How can media contribute in the development of a S&T Culture.
- Which media are more effective? Press, journals, radio, TV. , public lectures, internet?

Theme 20: TVET & S&T Education

- What are the present requirements of S &T in TVET?
- How can TVET and S&T education contribute to greater productivity?

Theme 21: S & T Curriculum

- Are the present S&T curricula conducive to the promotion of S&T?
- How can industry's needs be included in the S & T curricula?
- What network could be created between industry and educational institutions to promote S & T learning?

Theme 22: Technology in Vocational Training

- How is "Technology" taught in Vocational training?
- What can be done to improve the teaching of Technology in Training Institutions?
- How can ICT contribute to the teaching of Technology in Training Institutions?

Theme 23: Training of Technical Trainers

- What is the effectiveness of present pedagogical training of technical trainers involved in initial and in-service training?
- How can the effectiveness of the pedagogical training of technical trainers be improved?

Theme 24: Market Research

- What are the various spheres where Science and/or Technology is important?
- What are the approximate numbers of jobs needed?
- Who will carry out such market-oriented research?
- How will it be publicized?

Theme 25: Science and Technology Domains

- How to determine these domains?
- Who will carry out this research?
- What will be the positive outcome?

Theme 26: New research areas

- What are the various areas of science and technology where practically nothing is done in Mauritius?
- What would these areas being to the country?
- Where would the expertise be available?

Theme 27: To make the teachers become more effective

- How can teachers be motivated?
- How can teachers be given regular upgrading courses?
- Motivation through
    - Increase of salary?
    - Use of I.T?

  - Funds to be made available for improved facilities?
  - Opportunity for further training?

Theme 28: Inculcation of positive attitudes to life

- How can the teacher incite pupils to think positively?
- What should the teacher do so as to act positively?
  - Teacher Training/Seminars/Workshops?
  - Self-assessment?

Theme 29: Learning by doing

- How can teacher make pupils do more practical work?
- What should the teacher do to equip labs properly?
- Do teachers know about and use low-cost equipment for science and technology teaching?
- How can the lab be equipped fully?
  - Funds to be made available?
  - Teacher Training?
  - Change in assessment procedures?
- Role of science teacher associations

Theme 30: School based assessment

- How can the teacher carry out school based assessment objectively?
- How can 'non-examinable' subjects or components (like Physical Education, Music, Project Work, Field Work in Science, etc.) be assessed?
- What are the various criteria that could be used while carrying out school based assessment?
  - Teacher Training?
  - Change in scheme of assessment?
  - Curriculum review?

Theme 31: Popularising S&T Education at all levels

- How popular is S&T education at
  (i) Primary school level?
  (ii) Secondary school level?
  (iii) Pre-vocational school level?
- What makes S&T education popular or unpopular?
- What should be done to make S&T education more popular?
- Which institutions/agencies should help to make S&T education more popular?
- How to convince students/parents of the importance of S&T education?
- How to produce new curriculum/textbook for more popular science?
- How to produce student-friendly methods of assessment in S&T education?
- How to equip schools with equipment for popular S&T?
- How to train teachers for popular S&T?

Theme 32: The teaching/learning of S&T in schools

- Which is the perception of S&T teachers about their roles

- What is the perception of students about their purposes for learning S&T
- What are the facilities/resources available in school for the teach/learning of S&T?
- How much time is allowed for the teaching of S&T?
- What are the objectives of S&T education in schools?
- What are the methods/strategies used by teachers to teach S&T?
- How is S&T education evaluated?
- What should be done to improve the teaching/learning of S&T?
- How to make the teaching/learning of S&T more interesting for pupils?

Theme 33: The role of the Applied Science in S&T Education

- Which applied sciences are taught at present?
- How are the applied sciences taught?
- Are the syllabus relevant to the needs of the student and the needs of the country?
- What are the objectives of the applied sciences?
- How are applied sciences examined in schools?
- Are their links between schools and industry?
- Are student exposed to work sites where applied sciences are in application?

Theme 34: The Evaluation of S&T Education in schools

- What are the aims of evaluation of S&T education?
- How is the evaluation of S&T education organised?
- How much of knowledge, skills and attitudes are evaluated in S&T exams?
- What do students and teachers think about the way S&T education are evaluated?
- What are the bodies/agencies involved in the evaluation of S&T education?
- What should be done to improve the evaluation of S&T education in schools?

Theme 35: The S&T curriculum in schools

- How is S&T curriculum designed and planned?
- How is S&T curriculum implemented in schools?
- How is S&T curriculum evaluated in schools?
- Is there any quality control mechanism to ensure that the objectives are met?
- How is the S&T curriculum reviewed and how often?
- What are the curricular materials used for S&T teaching?
- What the strength & weakness of the S&T curriculum materials?
- What should be done to improve the S&T curriculum?
- How to popularise the S&T in schools?

Theme 36: Research in S&T education

- Which research projects has already been conducted in S&T education?
- What are the main findings, of these researches?

- Which areas have been researched and which areas have not?
- What were the objectives of the research?
- Who was involved in these research projects?
- Has the outcome of the researcher contributed to improving practice?
- How was the research funded?
- Which new areas warrant more attention for research?

Theme 37: Choice of Science and Technology by students and Teaching of Science and Technology

- What can be done to motivate students to take up S&T?
- What can be done to motivate Science teachers to improve their teaching?
- How can in-service courses help to improve teaching of S&T?
- How can multimedia be integrated into instructional materials to make learning of Science and Technology more interesting?
- What different teaching styles can promote learning of Science and Technology?
- Why must Information and Communication Technologies be an integral component of teaching of Science and Technology?

Theme 38: Training of Science Teachers?

- What are the training needs of Science teachers?
- What kind of support is needed by Science teachers?
- What training models can be used effectively and efficiently?
- The need for flexible professional development of Science teachers.
- The role of Science Associations, Teachers Unions and other professional bodies in improving teacher formation.

Theme 39: Use of Facilities

- Complaints about lack of equipment, material and chemicals in the science laboratories of the secondary schools are frequent.

- There is a need to study whether or not efficient and effective use is made of existing facilities. The study should also recommend the minimum requirements for science labs. together with how to optimise their use.

Theme 40: Use of low-cost equipment for science and technology teaching and learning

- How to revive such practice?
- Research into the effect of design of equipment by students and the learning-by-doing method in stimulating innovation.
- Publication or re-publication of guides for teachers on the use of low-cost equipment.

Annex B: Results of consultation with representatives of Cambridge International Examinations

Held on 2 July 2001 at UCLES, Cambridge

Present:

Dr M. Atchia for MRC

Dr Fred Burke)
Mr Anthony Dawson) for Cambridge International Examinations
Mr Simon Higgins)

Summary of Discussions

There is a continuous process at Cambridge of re-thinking examinations syllabuses and assessment practices.

This is always done in close consultation with the partners e.g. Local Examinations Syndicate such as the Mauritius Examinations Syndicate.

Assessment of practical work in science has to be fair to all, implementable and generally be seen to encourage practical work during the course.

The introduction of project work throughout the 2 years of "A" levels is deemed very useful specially for Science and Technology subjects. The assessment of such projects however makes use of school based assessment which has its pros and cons.

The use of "**alternative** to **practical"** has never meant neglect of practical work during the course, but is simply a method of assessment utilised where full practical examinations are not easily conducted.

To help in improving the level of Science and Technology in Mauritius three proposals are made below:

1. Introducing the new A/S level paper in **Thinking Skills** instead of General Paper. The paper tests rational thinking as a life skill needed by everyone.

2. Introducing more scientific and rational thinking into the General Paper itself, e.g. by having one or two questions on a description of an experiment, the provision of data and the testing of candidates in the way in which they analyse the data and reach a conclusion. Such an introduction would upgrade S&T in the eyes of all HSC students.

3. The introduction in Mauritius of two new Cambridge initiatives which are the **Cambridge Starter Awards in Information and Communications Technology** (for pupils of 6 to 16) and the **Cambridge Teaching with ICT Award** (for teachers), both meant to improve the status of ICT in Mauritius.

All the above suggestions need to be discussed at the level of the MES Council.

Annex C: Some guiding principles relating to the conduct of research

Eleven principles of research partnerships

- Decide on the objectives together
- Build up mutual trust
- Share information; develop networks
- Share responsibility
- Create transparency
- Monitor and evaluate the collaboration
- Disseminate the results
- Apply the results
- Share profits equitably
- Increase research capacity
- Build on the achievements

Checklist of questions relating to research projects carried out in partnership (South-North or South-South)

- Who originally proposed the project?
- Is the research question precisely formulated? Do all the participants understand it?
- Are the working hypotheses clearly formulated, and have the methods for addressing them been decided upon?
- Did all the relevant actors and people who will be affected by the research participate in developing the theme of the research?
- Does the project take the interests of all the participants into consideration, especially those of the final user in the South?
- Does the research planned fit into the partners' existing national or regional research policies?
- Does it serve the interests of all the partners?
- Does the proposed research give due consideration to the social, cultural, political, economic, ecological and technical needs and situation of the partners?
- If "yes", how?

(source: Swiss Commission for Research partnership with developing countries, KFPE, Bern 1998)

Annex D: List of international organisations which could collaborate, support or participate in the research proposed in this Report:

UNESCO	**:**	Headquarters, Place de Fontenoy, Paris (Science,Technology and Environment Education Section)
UNESCO-BREDA	**:**	Regional office for Education in Africa, Dakar, Senegal
UNESCO-ROSTA	**:**	Regional office for science & technology in Africa at UN complex, Nairobi, Kenya
SAREC-SIDA	**:**	Swedish Agency for Research Co-operation with Developing countries c/o Swedish International Development Agency
TWAS	**:**	Third World Academy of Sciences, Box 586, 34100, Trieste, Italy
KFPE	**:**	Swiss Commission for Research partnership with developing countries (KEPE), Bern, Switzerland.
ICASE	**:**	International Council of Associations of Science Education
ICSU	**:**	International Council of Scientific Union
IUBS	**:**	International Union of Biological Sciences, 51, Boulevard de Montmorency, Paris 75015.
IFS	**:**	International Agency for Science, Sweden
WFEO	**:**	World Federation of Engineering Organisations (Hq c/o UNESCO, Rue Miollis, Paris)
OECD	**:**	Organisation for Economic Co-operation & Development, OECD's Directorate for Science, Technology & Industry c/o OECD, Paris
ICSU-COSTED	**:**	ICSU committee on Science and Technology in Developing countries, 24 Gandhi Marday Road, Chennai, 600025, India
AAAS	**:**	American Association for the Advancement of Science, 1200 NY Avenue, NW Washington DC, 20005, USA
WIMSA	**:**	Western Indian Ocean Marine Research Association

Annex E: Sample of modern science curriculum

General Note

This sample is taken from a proposal made by the Cambridge International Examinations Syndicate for an "O" level in ENVIRONMENTAL MANAGEMENT". This proposal is at present being subject to broad consultations with participating countries (e.g. Mauritius, through the M.E.S.) and is to become operative in 2004.

Pedagogical Note

The syllabus is not a linear list of topics but a matrix linking together four main components of the natural environment: **lithosphere, hydrosphere, atmosphere, biosphere**, with four main aspects of environmental structure and processes: **resources, development, impact, management**.

Furthermore, it is stated upfront in the preamble that "the main aim of the syllabus is to encourage students to be actively involved in the conservation of the Earth's environments through the promotion of the concept of ***sustainable development*** and the syllabus therefore favours an ***interdisciplinary approach***".

At a consultative meeting held at M.E.S. in Réduit on 27 June 2001 it was proposed that the scheme of assessment (both for the "O" level and subsequent "A/S" level) must include project work carried out by students. Science is a practical subject and must remain taught through the ***active method*** (i.e. a resource-based methodology centred around the student's active participation at every stage) with assessment schemes reflecting this reality.

The Syllabus Matrix

- "O" Level Environmental Management Syllabus
- Cambridge International Examinations, May 2001

This is a provisional syllabus for consultation purposes only.

	RESOURCES	DEVELOPMENT	IMPACT	MANAGEMENT
Lithosphere	The lithosphere: Structure and processes Elements of soil	Human activity and the lithosphere	Lithosphere in crisis	Action on the lithosphere
Hydrosphere	The water cycle The oceans	Human intervention in the water cycle Exploitation of the oceans	Water hazards The oceans at risk	Clean, safe, water strategies Managing the oceans
Atmosphere	The atmospheric system	Human activity and the atmosphere Agriculture as a response to climate	Atmosphere in crisis Agriculture: development consequences	Action on the atmosphere Managing agriculture
Biosphere	The ecosystem Types of vegetation	The changing role of people in the environment Human population Modification of vegetation and soils	Ecosystems at risk People in crisis Land risk	Conservation of the ecosystem Population management Managing the land

Annex F: List of secondary institutions which could be utilised for pilot research projects for some of the educational research proposed in this Report.

Government Schools:

Queen Elizabeth College, Rose Hill
Dr Maurice Curé SSS, Vacoas
Mahatma Gandhi Institute, Moka
Gaëtan Raynal SSS, Belle Rose
Droopnath Ramphul SSS, Souvenir
Dunputh Lallah SSS, Curepipe
Royal College, Curepipe
Royal College, Port Louis
John Kennedy College, Beau Bassin
Dr Régis Chaperon SSS, Rose Hill
Sookdeo Bissoondoyal SSS, Rose Belle
Dayanand Anglo Vedic College

Private Confessional Schools:

B.P.S. College, Beau Bassin
Loreto College, Quatre Bornes
Loreto College, Port Louis
St Andrews College, Rose Hill
Hindu Girls College, Curepipe Road
Adventist College, Phoenix
Collège du St Esprit, Quatre Bornes
St Joseph College, Curepipe
Collège de la Confiance, Beau Bassin
Islamic Cultural College, Port Louis
Aleemiah College, Phoenix
Dayanand Anglo Vedic College

Private Schools:

London College
MEDCO Alex Bhujoharry
MEDCO, Trinity S.S.
Willoughby College, Mahébourg
Imperial College, Curepipe
Mauritius College, Curepipe
Presidency College, Curepipe
Eden College, Rose Hill
New Eton College, Rose Hill
Rodrigues College
Patten College, Rose Hill
Prof. B. Bissoondoyal College, Flacq
Ecole du Centre, P. Poivre, Helvétia
Le Bocage International School, Moka
Lycée Labourdonnais, Curepipe

Technical and Vocational Schools:

Lycée Polytechnique de Flacq
College St Gabriel, Ste. Croix
Sir R. Neerunjun Training Complex at Ébène (IVTB)

Annex G: Education Policy & Practices of a few selected countries[1]

A nation's education system is a critical element in its ability to function in today's high technology world and, consequently, to achieve and maintain a lead in aspects of the on-going Technology "War". Advanced industries have special needs for trained personnel at all levels of the work force. There is, for example, a significant need for engineers and technicians; new graduates are continually needed to do design work, create manufacturing facilities, and maintain sophisticated systems; computer scientists are needed to invent systems, develop system software, write applications software, and document systems. In addition, as manufacturing systems are called upon to meet new tolerances and engineering constraints, people need to have more formal technical training.

USA

The results of the U.S. educational system in science and technology in the twentieth century are impressive. Not only has the United States had more Nobel Prize winners than any other country, their achievements have been accompanied by wonderful technological innovations.

Unfortunately, over the last quarter of the century, there have been signs of a serious deterioration in technological innovation in the United States. Nobel Prizes seem to be more an accomplishment of the past than of the present. In fact, many of the recent prizes awarded to U.S. scientists have been won by foreign-trained people.

Another indication of the decline in creativity in the United States is the number of patent applications. In 1985, 43 percent of all patents issued in the United States went to foreigners and this figure has been declining ever since!

Only 16 percent of American secondary school students, for example, take any science or mathematics beyond tenth grade. And fewer and fewer American high school students elect mathematics and science courses. When they do, they are more likely to elect the life sciences rather than physics and chemistry. Only 33 percent choose chemistry and only 10 percent take physics. Fully 75 percent of American high school graduates do not have the prerequisites to enter a college science program.

When making comparisons with other countries, the U.S. position continues to slip. Japanese high school students take more advanced mathematics than most U.S. college students. France, Germany and Russia require four years of biology, chemistry and physics in high school. As for foreign language studies, the American efforts are overwhelmed by aggressive and linguistically curious partners and adversaries.

A major problem is the quality of teachers in the United States. Not only has the public too little respect for teachers, many teachers are not good enough. What is cause and what is effect? It is hard to say, but it is clear that teacher prestige is high in countries that have good educational systems. The elementary and secondary school system in the United States needs major revision and perhaps even minimum national requirements for students who enter and graduate from high school.

Japan

[1] after Brandin & Harrisson, The Technology War, University of California, 1994

Japanese educational practices contribute significantly to Japan's success in Technology. For example, Japanese high schools provide a substantially better grounding in mathematics, statistics, and basic science than almost all American high schools. In fact, Japanese secondary school students consistently score higher on standardized mathematics and science tests than any other students worldwide. Japan has a high degree of standardization in its high school curricula as well. Also, because of the stringent requirements of the university entrance examinations, there is a much smaller variation in Japanese students' backgrounds than in the United States.

In both the United States and Japan, institutions of higher education vary in terms of prestige.

Since the introduction of Western technology into Japan during the Meiji period, the engineering field has enjoyed relatively high status in Japanese universities and continues to attract large numbers of students. In fact, engineering is one of the paths into management in the large manufacturing companies of Japan, and therefore, it attracts potential managers as well as future engineers.

In Japan, graduates exit from a university training program with broadly based and extensive training in theory but, with fewer specialized and applied courses than their American counterparts. This education provides flexibility that is more useful in the general careers that await most Japanese graduates. But it also means that employers need to provide graduates with more time and structured orientation before they can be expected to make an independent contribution. Furthermore, since the best engineers in Japan are in companies, practical techniques can be taught in an industrial setting by experienced design engineers. Since a Japanese employee rarely leaves the company, this investment in pragmatic engineering is unlikely to be wasted. The result is that the Japanese engineer can and does receive a better education in practical engineering than in most countries of the world.

People's Republic of China

Because of extremely high unemployment rates among young people in China, (estimated 20 percent for the overall population) competition is stiff for entrance to universities. Only five out of every hundred applicants succeed in gaining admittance to Chinese universities, all of which are public. Unfortunately, due to a complex grading scheme and petition process for admission, even a very good student who has done well in his or her entrance exams might be rejected if the choice of university or the department in the university is oversubscribed.

Another problem with the Chinese education system is the lack of incentives although this is changing today with Chinese entrance into globalisation. It is true that entrance to a Chinese University computer science department is difficult, once a student has entered, the competition relaxes. Life in a university is quite good by Chinese standards. The student pays no tuition and gets partial support for room and board. Although the school year is long, forty-four weeks per year at six and one-half days per week, the demands placed upon students are relatively minimal. Further, when students are guaranteed a job upon graduation; high scholastic achievement does not necessarily result in a better job or better paying job. Finally, the quality of one generation of teachers is poor; the Cultural Revolution having effectively decimated the generation that today would be in its prime teaching or administrative years.

UK

United Kingdom's educational system should be outstanding: It has produced a disproportionate share of world class scientists based on the size of its population. Indeed, Britain has made fundamental contributions to computing, dating from Babbage, Lovelace and Turing to the present day. The system is geared to outstanding training for the elite. However, its educational system is lacking in many respects: The supply of ordinary engineers, scientists, and technicians is inadequate, in part because such people fail to command esteem in British society.

The British approach, which is still quite conservative in making capital investments in general, is even more so in making educational investments.

Salaries are only one facet of the comparative problems facing British professors. The young British professor at home must often cope with outmoded equipment and a lack of long-term prospects for adequate research funding. Many of the new British Universities (some of which like Brunel or Salford) grew out of colleges of advanced technology and are today giving the lead in practically based technical courses in engineering, transportation, environmental management, economics and computer technology. The various research councils have had a serious role to play in coordinating and directing R&D.

Federal Republic of Germany

West Germany has a solid elementary and secondary school program. Students entering the university are well grounded in mathematics and science. The German engineering tradition survives, and schools such as the Technical University in Munich and other technical universities as well as the universities of Berlin, Karlsruhe, Erlangen, Saarbrücken and Dresden are considered quite good in the international community.

Germany was quick to realize the importance of computer science (or *Informatik* as it is called in Germany) in the early 1970s. A national program was started in numerical analysis, mathematical physics, and parallel computation. Professorships were made available in many universities, and these very attractive lifetime positions were quickly filled with the best available people.

In East Germany (GDR), like in most countries of the eastern block, there was no competition and industries as well as universities were all centrally controlled. The result is that, after German re-unification in 1989, a lot of east German industries collapsed and had to be taken over by their western counterparts and their extremely proficient engineers and scientists had to be quickly trained for life in a competitive world (for example, in meeting worldwide standards, in marketing, in advertising etc..).

Russia

The situation in USSR was similar to that in GDR: centrally planned economies did not have to survive competition. Although USSR put the first men in space and developed the H-bomb it was lacking in the production of simple daily-life products of technology. The breakdown of USSR came as a rude shock as both universities and industries had to re-adjust to, firstly internal and eventually global markets. The strength of Russian and other C.I.S countries in science and technology is difficult to assess in 2001 as these countries are still in different phases of transition.

France

France has a distinguished scientific history and a strong traditional educational system. French history in physics and mathematics is, perhaps, unparalleled. However, the rigid French examination system stifles some creativity in students, as contrasted to the English system, which encourages it. Numerous Ministers of Education have since 1968 tried to reform the French education system but with limited success.

One of France's major problems is the lack of sufficient number of engineers from the *Grandes Ecoles*. Rigidity and very stiff entrance requirements has impaired the flow of new professorial talent into these French engineering schools. Only recently, when France recognized that it lagged in the technology race, did it become concerned about its inadequate supply of engineering graduates. Compounding the problem, a demographic study of French engineers showed that a large number of France's older engineers were soon to retire, and there was an inadequate number of French replacements for them.

Singapore

There is a direct link between educational quality, an adequate supply of graduates (in engineering, IT, science, management & commerce) and market share, employment **and** competitivity of products. The top level of the political ladder in Singapore understood this truth 30 years ago and everyone else followed the leadership, which goes a long way to explain Singapore's economic success.

India

The strengths and weaknesses of the Indian educational system have been closely followed by Mauritius due to the increasingly large number of Mauritians who study in India, both at undergraduate and post-graduate levels for academic, technical and professional pursuits.

Two recent local events have served to highlight India's advance in technology

(a) the offer of India, made at Prime Ministerial level, to assist Mauritius in developing its cyber-capacity.

(b) The organisation and funding of teaching and research at tertiary level in India, as described by the Chairman of its University Grants Commission during a visit to Mauritius.

Annex H: Bibliography

Listed below are published results of some recent research related to S&TE which may be referred to by those who will engage in the research projects proposed in this Report

Georgios Tsaparlis and Vasilcios Angclopoulos – A MODEL OF PROBLEM SOLVING: ITS OPERATION, VALIDITY, AND USEFULNESS IN THE CASE OF ORGANIC-SYNTHESIS PROBLEMS - Science Education – *March 2000*

Mary Monroe Atwater – EQUITY FOR BLACK AMERICANS IN PRECOLLEGE SCIENCE – Science Education - *March 2000*

Gail Jones, Ann Howe, and Melissa J. Rua – GENDER DIFFERENCES IN STUDENTS' EXPERIENCES, INTERESTS, AND ATTITUDES TOWARD SCIENCE AND SCIENTISTS – Science Education – *March 2000*

Hugh Munby, Malcolm Cunningham, and Cinde Lock – SCHOOL SCIENCE CULTURE: A CASE STUDY OF BARRIERS TO DEVELOPING PROFESSIONAL KNOWLEDGE – Science Teacher Education – *March 2000*

Debra Tomanek and Katharine E. Cummings – THE USE OF SECONDARY SCIENCE CLASSROOM TEACHING ASSISTANT EXPERIENCES TO RECRUIT ACADEMICALLY TALENTED SCIENCE MAJORS INTO TEACHING – Science Teacher Education – *March 2000*

Douglas Macbeth – ON AN ACTUAL APPARATUS FOR CONCEPTUAL CHANGE – Learning – *March 2000*

Deborah J. Trumbull, Rick Bonney, Derek Bascom, and Anna Cabral – THINKING SCIENTIFICALLY DURING PARTICIPATION IN A CITIZEN-SCIENCE PROJECT – Informal Science – March 2000

Rosalind Driver, Paul Newton, and Jonathan Osborne – ESTABLISHING THE NORMS OF SCIENTIFIC ARGUMENTATION IN CLASSROOMS – Science Education – *May 2000*

Enrique Banet and Enrique Ayuso – TEACHING GENETICS AT SECONDARY SCHOOL: A STRATEGY FOR TEACHING ABOUT THE LOCATION OF INHERITANCE INFORMATION – Science Education – *May 2000*

*Allan G. Harrison and David F. Treagus*t – LEARNING ABOUT ATOMS, MOLECULES, AND CHEMICAL BONDS: A CASE STUDY OF MULTIPLE-MODEL USE IN GRADE 11 CHEMISTRY – Science Education – *May 2000*

Christina Solomonidou and Heleni Stavridou – FROM INERT OBJECT TO CHEMICAL SUBSTANCE: STUDENTS' INITIAL CONCEPTIONS AND CONCEPTUAL DEVELOPMENT DURING AN INTRODUCTORY EXPERIMENTAL CHEMISTRY SEQUENCE – Science Education – *May 2000*

M. B. Ogunniyi – UNITWIN/UNESCO CHAIRS PROGRAM AND CAPACITY BUILDING IN SCIENCE AND TECHNOLOGY IN SOUTHERN AFRICA – Science Education - Culture and Comparative Studies – *May 2000*

Pradeep M. Dass – THE FORGIVING AIR: UNDERSTANDING ENVIRONMENTAL CHANGE – *Science Education* – The Books – *May 2000*

Kathleen Hogan – STORM OVER A MOUNTAIN ISLAND: CONSERVATION BIOLOGY AND THE MT. GRAHAM AFFAIR - Science Education – *May 2000*

Steve Sizmur – PORTRAITS OF PRODUCTIVE SCHOOLS: AN INTERNATIONAL STUDY OF INSTITUTIONALIZING ACITIVITY-BASED PRACTICES IN ELEMENTARY SCIENCE – Science Education – *May 2000*

William W. Cobern – EDITORIAL: TALKING ABOUT ISSUES – Science Education, Science Teacher Education Section Paper Set – January 2001

Bradford F. Lewis and Glen S. Aikenhead – INTRODUCTION: SHIFTING PERSPECTIVES FROM UNIVERSALISM TO CROSS-CULTURALISM – Science Education – January 2001

Gloria Snively and John Corsiglia – DISCOVERING INDIGENOUS SCIENCE: IMPLICATIONS FOR SCIENCE EDUCATION – Science Education – *January 2001*

William B. Stanley and Nancy W. Brickhouse – TEACHING SCIENCES: THE MULTICULTURAL QUESTION REVISITED – Science Education – *January 2001*

William W. Cobern and Cathleen C. Loving – DEFINING “SCIENCE” IN A MULTICULTURAL WORLD: IMPLICATIONS FOR SCIENCE EDUCATION – Science Education – *January 2001*

Henry Augustine Brown-Acquaye – EACH IS NECESSARY AND NONE IS REDUNDANT: THE NEED FOR SCIENCE IN DEVELOPING COUNTRIES – Science Education – *January 2001*

Gurol Irzik – UNIVERSALISM, MULTICULTURALISM, AND SCIENCE EDUCATION – Science Education – *January 2001*

Elizabeth McKinley – CULTURAL DIVERSITY: MASKING POWER WITH INNOCENCE – Science Education – *January 2001*

Bernard R. Ortiz de Montellano - MULTICULTURAL SCIENCE: WHO BENEFITS? – Science Education – January 2001

Margareta Svennbeck – RETHINKING THE DISCUSSION ABOUT SCIENCE EDUCATION IN A MULTICULTURAL WORLD: SOME ALTERNATIVE QUESTIONS AS A NEW POINT OF DEPARTURE –Science Education – *January 2001*

John Corsiglia and Gloria Snively – REJOINDER: INFUSING INDIGENOUS SCIENCE INTO WESTERN MODERN SCIENCE FOR A SUSTAINABLE FUTURE – Science Education – *January 2001*

William B. Stanley and Nancy W. Brickhouse – RESPONSE TO OUR CRITICS – Science Education – *January 2001*

Ken King, Lee Shumow, and Stephanie Lietz – SCIENCE EDUCATION IN AN URBAN ELEMENTARY SCHOOL: CASE STUDIES OF TEACHER BELIEFS AND CLASSROOM PRACTICES – Science Education – *March 2001*

Philip M. Sadler and Robert H. Tai – SUCCESS IN INTRODUCTORY COLLEGE PHYSICS: THE ROLE OF HIGH SCHOOL PREPARATION – Science Education – *March 2001*

David F. Treagust, Roberta Jacobowitz, James L. Gallagher, and Joyce Parker –USING ASSESSMENT AS A GUIDE IN TEACHING FOR UNDERSTANDING: A CASE STUDY OF A MIDDLE SCHOOL SCIENCE CLASS LEARNING ABOUT SOUND – Science Education – *March 2001*

Martina Nieswandt – PROBLEMS AND POSSIBILITIES FOR LEARNING IN AN INTRODUCTORY CHEMISTRY COURSE FROM A CONCEPTUAL CHANGE PERSPECTIVE – Science Education – *March 2001*

Glen S. Aikenhead – STUDENTS' EASE IN CROSSING CULTURAL BORDERS INTO SCHOOL SCIENCE – Culture and comparative Studies - Science Education – *March 2001*

Ellen K. Henriksen and Doris jorde – HIGH SCHOOL STUDENTS' UNDERSTANDING OF RADIATION AND THE ENVIRONMENT: CAN MUSEUMS PLAY A ROLE? – Informal Science – Science Education – *March 2001*

James Stewart and John L. Rudolph – CONSIDERING THE NATURE OF SCIENTIFIC PROBLEMS WHEN DESIGNING SCIENCE CURRICULA –Science Education – *May 2001*

Jospeh I. Polman and Roy D. Pea – TRANSFORMATIVE COMMUNICATION AS A CULTURAL TOOL FOR GUIDING INQUIRY SCIENCE – Science Education – *May 2001*

Michael T. Hayes and Donna Deyble – CONSTRUCTING DIFFERENCE: A COMPARATIVE STUDY OF ELEMENTARY SCIENCE CURRICULUM DIFFERENTIATION – Science Education – *May 2001*

Zougui Deng – THE DISTINCTION BETWEEN KEY IDEAS IN TEACHING SCHOOL PHYSICS AND KEY IDEAS IN THE DISCIPLINE OF PHYSICS – Science Education – *May 2001*

France Lawrenz, Douglas Huffman, and Wayne Welch – THE SCIENCE ACHIEVEMENT OF VARIOUS SUBGROUPS ON ALTERNATIVE ASSESSMENT FORMATS – Science Education – *May 2001*

Stein D. Kolsto – SCIENTIFIC LITERACY FOR CITIZENSHIP: TOOLS FOR DEALING WITH THE SCIENCE DIMENSION OF CONTROVERSIAL SOCIO-SCIENTIFIC ISSUES – Issues and Trends – Science Education - *May 2001*

Hugh Munby, Malcolm Cunningham, Cinde Lock – SCHOOL SCIENCE CULTURE: A CASE STUDY OF BARRIERS TO DEVELOPING PROFESSIONAL KNOWLEDGE – Science Teacher Education – *March 1999*

Gail Jones, Ann Howe, Melissa J. Rua – GENDER DIFFERENCES IN STUDENTS' EXPERIENCES, INTERESTS, AND ATTITUDES TOWARD SCIENCE AND SCIENTISTS – Science Teacher Education – *March 1999*

Ellen K. Henriksen, Doris Jorde – HIGH SCHOOL STUDENTS' UNDERSTANDING OF RADIATION AND THE ENVIRONMENT: CAN MUSEUMS PLAY A ROLE? – Informal Science – *September 2000*

John Settlage – Understanding the Learning Cycle: INFLUENCES ON ABILITIES TO EMBRACE THE APPROACH BY PRESERVICE ELEMENTARY SCHOOL TEACHERS – Science Education – *January 2000*

Kathleen Hogan – EXPLORING A PROCESS VIEW OF STUDENTS' KNOWLEDGE ABOUT THE NATURE OF SCIENCE – Science Education – *January 2000*

Rudiger C. Laugksch – SCIENTIFIC LITERACY: A CONCEPTUAL OVERVIEW – Science Education – *January 2000*

Yehudit J. Dori and Revital T. Tal – FORMAL AND INFORMAL COLLABORATIVE PROJECTS: ENGAGING IN INDUSTRY WITH ENVIRONMENTAL AWARENESS – Science Education – *January 2000*

Edgar W. Jenkins – AN HISTORICAL AND PERSONAL VIEW OF THE ASE AND ITS PREDECESSORS AND A LOOK INTO ITS FUTURE – School Science Review – *March 2001*

J. F. Donnelly – SCHOOL SCIENCE TEACHING AS A PROFESSION: PAST, PRESENT AND FUTURE - School Science Review – *March 2001*

Philip Adey – 160 YEARS OF SCIENCE EDUCATION: AN UNCERTAIN LINK BETWEEN THEORY AND PRACTICE - School Science Review – *March 2001*

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