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ABSTRACT

This book is the report of the UNESCO/APEID Regional Workshop on Science and Technology Education at Lower Secondary Level. Part I is the Source Book which has three chapters. Chapter 1 is on emerging policy and strategy aspects for science and technology education at the lower secondary level. Chapter 2 discusses the implications for teacher training and orientation of other education personnel, the community, and parents. Chapter 3 contains examples of application to real-life situations. This part has been written in the form of a source book for reform of science and technology education at the lower secondary level. It discusses the kind of science and technology that will be required in the next decade. It analyzes issues that need to be resolved when reforming science and technology education to achieve current interpretations of Science for All. It offers options, analyses, case studies, and examples rather than prescriptions. Part II, Country Experiences, is a review of country experiences presented by the participants/resource persons from Australia, Bhutan, People's Republic of China, India, Indonesia, Lao People's Democratic Republic, Malaysia, Maldives, Nepal, Pakistan, Philippines, and Thailand. (PR)

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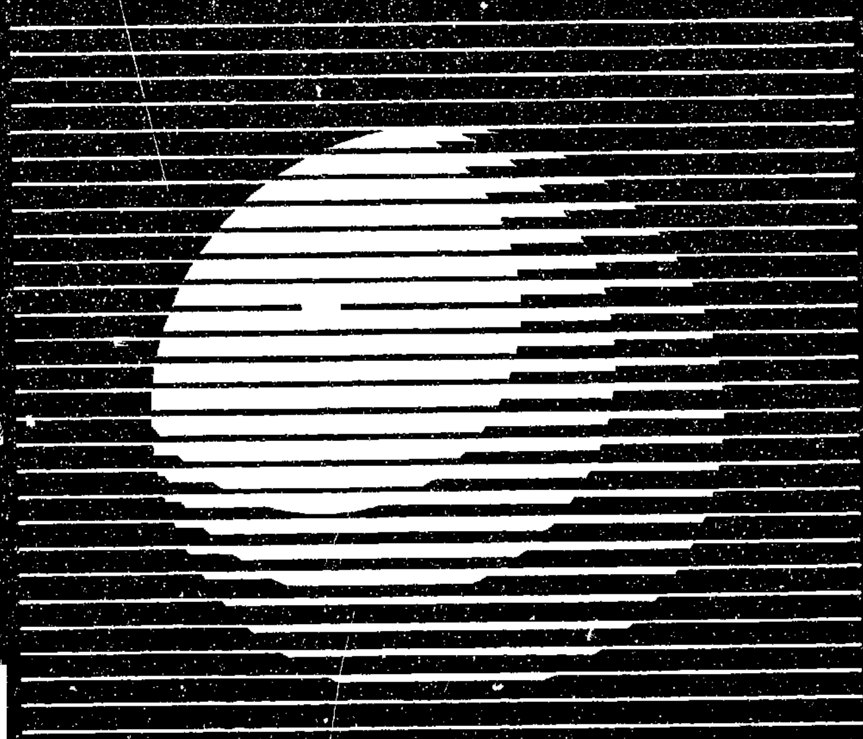

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Preface

"Science for All and the Quality of Life" is the report of the UNESCO/APEID Regional Workshop on Science and Technology Education at Lower Secondary Level, held in Kathmandu, Nepal, 12-21 March 1990. It is published in two parts.

Part I is the Source Book which has three chapters. Chapter One is on emerging policy and strategy aspects for science and technology education at the lower secondary level. Chapter Two discusses the implications for teacher training and orientation of other education personnel, the community and parents. Chapter Three contains examples of the application to real-life situations. This part has been written in the style of a source book for reform of science and technology education at the lower secondary level. It discusses the kind of science and technology education required in the next decade. It analyses issues that need to be resolved when reforming science and technology education to achieve current interpretations of Science for All. It offers options, analyses, case studies, and examples rather than prescriptions.

Part II: Country Experiences is a review of country experiences presented by the participants/resource persons from Australia, Bhutan, People's Republic of China, India, Indonesia, Lao People's Democratic Republic, Malaysia, Maldives, Nepal, Pakistan, Philippines and Thailand.

The report provides in the first instance a record of the deliberations of the workshop. It also provides guidance for curriculum and policy development in the Member States.

Introduction

UNESCO PROAP/ACEID, in cooperation with the Ministry of Education and Culture, HM Government of Nepal, the Science Education Development Centre (SEDEC), and the Curriculum, Textbook and Supervision Development Centre, Nepal, convened a Regional Workshop on Science and Technology Education at Lower Secondary Level in Kathmandu, Nepal, from 12-21 March, 1990.

The activity was a component of the 1990 programme of UNESCO/APEID and the UNDP assisted project RAS/86/051 – Improvement of Science and Technology Education.

The Workshop supported current deliberations on science and mathematics education of HM Government of Nepal by placing the rich experiences of the region at the disposal of policy planners and curriculum developers of Nepal. It followed a National Seminar on Science and Mathematics Education Policy and Planning held in Nepal between 11 - 16 February, 1990.

The Workshop focused on:

- Policy and strategy related to science and technology education for all at lower secondary level;
- Application of learning in science and technology to real life situations in the students' environment, with particular reference to improving the quality of life and productivity;
- Implications for curriculum development and pupil evaluation, including the affective domain;
- Implications for teacher training, and for community/parental involvement; and
- Planning and implementation difficulties.

Deliberations were supported by extensive presentations from countries in the region with several years of experience in reforming science and technology education at lower secondary level. The presentations included examples of curricula, learning sequences, learner evaluation instruments, audio-visual aids, equipment, and teacher training designs, in addition to analyses of new policies.

Participation/Preparations

Eleven countries provided thirteen participants and four observers to the Workshop. Two resource persons assisted in the deliberations.

Mrs. Kristie Regan, Assistant Programme Officer, UNDP, Nepal attended a session of the Workshop, as did experts from Nepal.

Each participant presented and provided an analytical country comment (Part II) incorporating the following elements, with reference to science and technology education at lower secondary level:

- Recent policies and strategies in science and technology education, with particula ˜erence to Science for All, and implications for curriculum development.
- Planning and implementation difficulties, and actions taken to overcome these.
- Examples drawn from current curricula, of applications of (classroom) science and technology learnings in real life situations in the local milieu, with particular reference to improving the quality of life and productivity of the learners and their communities.
- Examples drawn from current curricula, of pupil achievement evaluation instruments, including evaluation of the affective domain.
- Examples drawn from current practice, of designs for teacher education in support of these reforms.

Office Bearers and Resource Persons

The following acted as Office Bearers of the Workshop:

Chair-Person	:	Dr. Thongchai Chewprecha, Thailand
Vice Chair-Person	:	Dr. J. S. Gill, India
Rapporteur	:	Mrs. Erlinda Y. Basa, Philippines

Ratnaike, J., UNESCO PROAP/ACEID, acted as the Secretary to the Workshop. The resource persons were Dr Cliff Malcolm, Australia, and Dr. J. S. Rajput, India. Substantive and technical support were provided by Mr. Toran B. Karki, Director, SEDEC and his staff.

Workshop Activities

Deliberations took place in whole group, small groups and individual work sessions. The production of the report was undertaken by two working groups formed by the participants, supported by the resource persons. Presentations, discussions and readings were mixed with writing sessions.

Inaugural Session

The Workshop was opened by the Secretary of Education, Mr. Ramesh Jung Thapa. In his address, he indicated that during Nepal's Seventh Development Plan (1985 - 1990), HM Government developed a detailed programme aimed to fulfil the basic needs of the nation by the end of the century. In addition to food, clothing, fuel, shelter, drinking water, primary health care and sanitation, transport and security etc., primary education (covering the first five grades) was declared a basic need to be provided to all children of relevant age in the kingdom. Accordingly primary education has been made free.

Realizing the potential and scope of science and technology in solving such problems and to help achieve the fulfilment of basic needs, policy provisions of HM Government emphasize the development of science and technology through efficient and effective utilization of human and material resources. As a measure of this policy, science has been made an essential component of the school curriculum.

These changes confront HM Government with problems of revision of school science curricula, development of innovative teacher education programmes and preparation of more suitable student evaluation procedures.

Science and technology are recognized as essential factors contributing to progress and peace in the world. The success of a society depends on how effectively and extensively it can absorb and use scientific and technological knowledge and skills in developing its potential. In a modern society, science and technology represent two basic human activities, which relate to asking questions and solving problems. As such, they constitute an intellectual strategy which every learning human being in urban and rural areas alike should adopt for day to day decision-making. Further, they provide powerful tools in finding, knowing, understanding and doing things in better ways. Any education that does not take full cognizance of both science and technology is incomplete, irrelevant, and fails its purpose.

The current cry of "Science For All" reflects the recognition of the capacity of science and technology to improve the quality of life for the individual, community and the nation as a whole. One of the major goals of science education is to generate, develop and transfer such knowledge and skills as are necessary for the promotion of the welfare of the people and socio-economic development of the country. A scientifically informed and technologically literate population provides not only the broad base from which qualified manpower can be developed, but also it helps create a climate in which innovative technologies can take root and flourish.

The Secretary of Education wished the Workshop great success in its deliberations and thanked UNESCO for selecting Kathmandu as the venue. He welcomed the participants to Kathmandu and wished them a pleasant and remarkable stay.

Purposes of the Report

The report provides in the first instance a record of the deliberations of the Workshop. It provides also guidance for curriculum and policy development in the member states.

It has been written in the style of a guidebook for reform of science and technology education at the lower secondary level. It discusses the kind of science and technology education required in the next decade. It analyses issues that need to be resolved when reforming science education to achieve current interpretations of Science for All. It offers options, analyses, case studies, and examples rather than prescriptions.

Conclusions

The conclusions and recommendations derived from the deliberations of the Workshop are as follows:

1. The concept of *Science for All* is not to be viewed only in the context of the school curriculum, but as a component of the totality of efforts in universalizing education, including alternative strategies like non- formal education, adult education etc.
2. While the majority of countries in the region have included *Science for All* in their policy formulation and have translated it into school curricula, it is recommended that other countries also do so at the earliest, at least up to lower secondary stage.
3. Each nation may attempt to define and determine the 'learning needs' of the children and also 'quality of life' in the changing context of the growing impact of science and technology. The outcomes, related to 'real life situations' may be utilized in curriculum renewal, which has to be a regular and on-going process.

4. It is to be ensured that a proper mechanism of monitoring and evaluation is established which develops appropriate tools, instruments and mechanisms for the purpose and also trains personnel to perform the tasks objectively.

5. In-service and pre-service teacher education training strategies need to be modified. The programmes should prepare teachers to adopt creative teaching models improvising, experimenting, innovating, and utilizing community resources. Teacher education should encourage teachers to make school teaching more joyful, participatory and related to local needs and aspirations.

6. Apart from teacher training institutions, each country may establish or augment resource centres for curriculum development and for assisting teachers. These centres would provide regular professional support in solving the problems of teachers which they may experience in the curriculum and in teaching.

7. Policy changes, curriculum renewal and modified strategies for monitoring and evaluation, need to be communicated not only to all education personnel, but also to opinion leaders, and parents with equal emphasis. Acceptance should be ensured as well as modification of curricula.

8. School-community relationships may be strengthened with mutual accountability established. This helps in resource management, better understanding and appreciation of existing community needs, and futures projection. Further, this helps build affective domain components like attitudes, social sensitivity and responsibility, among all concerned, and strengthens the partnership between school and community in the education of children.

9. Teachers' Associations should be established and strengthened. These may function as professional forums and teacher support systems.

10. Whenever feasible, audiovisual aids and electronic technology may be utilized. Teachers may be provided with bulletins, newsletters, new innovation brochures and other print materials as well.

11. Assistance from agencies like Unesco maybe taken to supplement in-country projects for experience-sharing inputs.

12. Sharing of experiences at different levels amongst countries undergoing similar changes may be encouraged by UNESCO.

Part One

SOURCE BOOK

Chapter One

Emerging Policy and Strategy Aspects for Science and Technology Education at Lower Secondary Level

This chapter proposes a definition of Science For All for curriculum development in the next decade and describes some of the factors which have given rise to that definition. It also examines ramifications of the definition for policies and processes in curriculum development and implementation.

1. Science for All : The New Interpretation

Science and technology are greatly important to human well being and the quality of our environment. Socio-economic progress without science and technology is impossible. Science and technology can help to reduce misery, poverty, hunger, diseases, social injustice, energy crisis, environmental pollution and other global problems.

Universalization of science and technology education is essential. Science and technology education should be available for all human beings without discrimination of race, religion, caste, ideology, socioeconomic background, gender, or region.

- All students at the junior secondary levels of schooling should study science and technology.
- All students gain from their studies of science and technology; the objectives, teaching approaches and assessment strategies should be chosen to suit the needs and backgrounds of all students in the group.
- *Science for All* is not only benefiting individuals, but the collective good of the community and humanity as a whole.

1.1 Features of Science for All

i) Schools, teachers, classroom materials, audio-visual aids, workshop facilities and equipment must be accessible to all students.

ii) The content, language, symbols, designs and purposes of the curriculum should link to the day to day experiences and purposes of the children. This requires some curriculum development at the local level, responsive to the needs and interests of the children in the locality.

iii) Science and technology education should make a difference to the way students think about their world and the things they do. It should link theory to practice, human purpose and the quality of life; reflection to action; in-school experience to out-of-school experience.

iv) Teaching and learning should begin from the beliefs, interests and learning skills that students bring to the classroom, and help each of them to extend and revise their understanding and their ability.

v) Some learnings have particular value in relation to further learning and employment. Such learnings should be accessible to all students equally.

These features are embraced in an approach which we will refer to as *Science, Technology, Society, Personal Development (STSP)*.

Science refers to theoretical knowledge and the processes by which it is generated and tested. This theoretical knowledge is a response to the question "I wonder...."

Technology is the solution of practical problems, and the devices and systems that have been developed as a consequence. It is a response to the question "I want...." Technological development has been greatly enhanced by its links to science; science depends strongly on its use of technology.

Society recognizes the social and human context that gives purpose to science and technology, and the impact that science and technology have on our lives. The *society* aspect includes questions "Should we...."

The *Personal Development aspect* recognizes the possibilities within the science curriculum to enhance students' personal skills in logical thinking, expression, personal management, self-directed learning, cooperation, and responsible action. It implies purposes within the science curriculum to assist students to develop and refine their world-view and to take effective and responsible action in their own lives and as part of their community. It recognizes that education needs to address the development of the individual both as an individual person and as a member of society.

The curriculum should give attention to each of science, technology, society and personal development, and they should be integrated in their development.

2. Factors Which Have Led to This Interpretation

2.1 Approaches to social and economic development

The importance of science and technology in social and economic development have been understood for a long time. However, strategies of development have changed over the last three decades.

During the 1960s and 1970s, many countries concentrated on training a work-force who could use technology. The technologies themselves were often imported, and so were the experts who provided the technical knowledge and management. The investment in equipment etc. often came from overseas, and many of the profits went back overseas. Frequently, raw materials were exported for processing and then imported as finished products at high prices.

During the 1980s, the strategy shif' : towards creating a work-force which could develop new technologies themselves. By their inventiveness, the work-force produces exportable goods and techniques whose value is much greater than that of the raw materials. This trend continues in the 1990s.

The need in the 1990s is not only for people who can lead technological development and work in science-based industries. The working and living environment is increasingly technological. All people need to be comfortable in that environment and contribute to the use and wise management of technology.

2.2 Environmental Conservation

The impact of human activities on the natural environment has become increasingly clear over the last decade. Action at the national, community and individual levels is now imperative for long term survival. We have to use existing technologies more carefully and develop new or alternative technologies which conserve resources and the environment.

2.3 Basic Needs

There are some communities and individuals in our countries whose basic needs of hygiene, health, education, nutrition, shelter and clothing are not being met. Their quality of life can be greatly improved if they are educated in simple techniques of, for example, hygiene, use of water, preparation and choice of food, and looking after animals.

2.4 Educational Purposes

The achievement of the economic development, environmental management and improved quality of life outlined above requires education that is aimed not simply at knowledge but at action. This action is required at an individual level, and also at the level of the local community and the whole society. Therefore, the curriculum must assist individuals to take action, and to participate in community action.

The curriculum must also address the development of the individual, assisting that person reaches his/her potential as a human being. This requires assisting the student to develop a world view, integrating values and knowledge from different realms of experience and thought, and linking concepts of self to concepts of society and environment, spirituality and justice.

In the 1960s, the orientation of the science curriculum was science is what scientists do: their methods of developing and testing scientific knowledge, and the concepts and theories that are central to the scientific disciplines. Little attempt was made to link this knowledge to technological applications, social concerns, or the daily experiences of the students.

In the 1970s the orientation shifted to the functionality of science, especially for those who would not enter universities. *Science, Technology, Society* education arose from this trend. It linked science to technology and placed them both in the context of social needs and everyday life. The emphasis shifted from "What do I know", to "What can I do ?"

In the 1980s, at least in a few countries, a further change has emerged, with science and technology education becoming a central component of the education of all citizens, so that they can become responsible, productive citizens. The emphasis is shifting towards the social action described above, and the question "Who am I becoming ?" This requires more attention to teaching children how to learn, manage their own learning, analyze problems and design and implement solutions. Thus the slogan *Science, Technology, Society* is extended to *Science, Technology, Society, Personal Development*. (STSP).

Dimension	**Learning for Knowing(1960s)**	**Learning for Applying(1970s)**	**Learning for Being/Becoming (1980s)**
Philosophy	Positivism	Utilitarianism	Constructivism
Focus	What do I *KNOW*?	What can I *DO*?	Who I am *BECOMING?*
Knowledge produced	Propositional	Practical	Experiential
Structure	Subject/Discipline	Subject/Discussion Craft/Technology	Issues (micro and macro)/Subject/ Discussion
Teacher Role	Expert/Information Giver	Applier	Facilitator
Teaching/ learning strategy	Didactic	Practical	Real life problem solving

2.5 Research into Children's Learning

Recent research provides compelling evidence that:

- Students develop theories and beliefs about the way the world operates, from their experiences with a range of objects and people at home, at play and at school;
- These beliefs are strongly held and little affected by traditional instruction. Traditional instruction often makes little impact on the ways children think about the world or act in it, even when it is coupled with experiments and active learning.

This has led to a view of learning as the construction of new meanings in the light of experience. It is called "constructivist". It contrasts with a view of learning as the reception or acquisition of knowledge.

Students, in the course of growing up, develop their own strategies for learning and constructing meaning. They can be taught to develop effective strategies, and this should be an integral part of the curriculum.

Research has shown also that when students are taught strategies of effective learning in one area (say science), they are able to apply these strategies successfully in other areas.

Constructivist learning requires different approaches to teaching, assessment and classroom management. Teaching needs to start from the beliefs that students already hold and then extend or revise those beliefs.

It is important that students have opportunities to express their current understandings, perhaps through drawing or talking. Similarly, in clarifying their learning strategies, they need opportunities to share with other students, their teacher, and other members of the community.

In expressing their own thoughts and understandings, students take a risk of being seen as foolish by their teachers or fellow students. Hence it is important that the climate of interaction in the classroom is co-operative.

If student's beliefs and experiences are inputs to the learning situation, then students are effectively involved in developing lessons and planning the curriculum.

Constructivist approaches link to co-operative learning and participative management. The shift towards participative management in classrooms parallels recent developments in agriculture, industry and public administration. In the classroom and in business, an important objective of participative management is to encourage creativity and flexibility.

2.6 Social Justice

Over the last two decades, there have been significant shifts in the definition of social justice. In the past "equal opportunity" was presumed to be satisfied if there was freedom for individuals to apply for jobs and promotion, receive health care, enter institutions or obtain services, regardless of their ethnic background, religion, gender, socio-economic background or any disability. However this apparent access is an illusion if individuals do not have money to pay, if their language is not the language of the institution, if their disability restricts their movement, if prejudice and social structures reduce their prospects of success. Current concepts of social justice recognize these barriers and attempt to overcome them. The shift, in essence, is a shift from "equal treatment" to "equal access" where access is measured not only by availability of a ser.ice or opportunity for an individual to use it successfully.

3. Preliminary Considerations: Planning for Science for All

Thorough planning and preparation for educational change and curriculum development are essential for successful implementation. Planning needs to take care of the relationships between educational policies and other policies and programmes; the administrative structures required for formulating, implementing and supporting the changes; and the human and material resources that are necessary. Factors to be considered and issues that arise in planning Science for All are discussed below.

3.1 Dimensions of Policy

Science education policies are influenced by national policies in areas like agriculture, industry, science, environment, and social welfare. Protection of the environment is now a common component of school science. Policies which shift national pr'orities from traditional to scientific agriculture, and from *using* to *developing* industrial technology influence the science curriculum. There are also special policies for some categories of people like disabled, women, economically backward, tribal and rural populations.

Policies are developed at different levels, from statements of broad vision and direction to specific arrangements for implementation. The recruitment and preparation of teachers, work conditions, administrative structures at the school and system levels, and provision of buildings, facilities, and instructional materials require policies at the implementation level.

Planning and implementation of curriculum are often worked out in the form of frameworks and guidelines. They spell out curricular content, organization, and the roles of teachers, parents and school administrators. Materials to support curricular implementors and other functionaries are also essential.

Policies in science curriculum for improvement of the quality of life must consider the meaning of "quality of life":

- economic and industrial development
- preservation of national culture and heritage
- spiritual and moral development
- social and economic justice
- equality of opportunity
- respect for individuals, society, constitution and law
- judicious and rational use of the environment and its resources
- maintenance and improvement of the quality of the environment
- understanding the place of science and technology in our society and the role they can have in improving the quality of life

These considerations might lead to objectives of science education like: "*The science curriculum will help students to develop progressively to:*

- *understand some of the methods, concepts and theories that scientists use, and the ways science is applied in our everyday lives*
- *understand the role of technology and the world of work*
- *develop knowledge, skills and attitudes essential for contributing to development and improvement of life*
- *develop interest, critical thinking and the spirit of enquiry*
- *develop skills in identifying and solving problems and making decisions and taking action*
- *develop open mindedness, tolerance and respect*
- *develop to the full learners' potential for human expression and achievement*
- *develop habits of team work and cooperation*
- *expand their vision for global concerns*
- *respect and use natural resources judiciously and sensibly*".

3.2 Dimensions of the Curriculum

The curriculum is more than a list of objectives or things to be learned. It includes all the aspects necessary for "good learning" to take place for every student in the class.

Some teaching methods provide better opportunities than others for all students to participate and succeed in the learning. Teaching methods need to be chosen also to suit the different learning styles of individual students and the range of learning objectives of "Science for All".

Assessment strategies are not only methods of measuring educational achievement. They make important statements about the kinds of learning and the kinds of achievement that are valued by the school system, and also influence strongly the learning that occurs. If the curriculum is oriented to problem solving in the context of daily life, students "becoming", and "learning how to learn" as well as "knowing" and "doing", progress in these objectives needs to be part of the assessment. If the only assessment is by national tests at points through the programme, it is unlikely that the curriculum in practice will give serious attention to local concerns and needs.

Facilities, the ways students are grouped, school policies about noise levels and excursions, timetabling, all affect the access that students have to successful learning. Co-operative learning cannot succeed if the general ethos of the school is one where students are ridiculed for wrong answers, or where there is strong emphasis on competition.

If the curriculum is to link to the daily lives of the students there must be mechanisms to strengthen the partnership between parents, students, teachers and the community. Learning is enhanced when there is consonance between school, home and community.

Similarly, learning is enhanced when there is consonance among the curricula in different subject areas. The science curriculum should not be an isolated entity in itself. It should be an integral part of the school curriculum as a whole.

3.3 Choosing the Content

In a science curriculum which draws its content from science, technology, the cultural and human context of science, and applications of science to improve the quality of life, many topics and approaches are rich with possibilities. No longer is "basic content" defined simply from "the basic structure of the disciplines of science". "Basic" now has to be defined in relation to the needs and aspirations of the students, their communities, and the nation. It follows that the definition of "basic content" must vary somewhat from locality to locality and person to person.

Criteria for selecting content, whether at the central level, the local level or both, need to be established as part of science education policy. For example, is the content,

- based on the interests and experiences of the children, founded on action and able to assist students to understand everyday phenomena?
- accessible to pupils through the use of inquiry skills and suited to further development of those skills?
- attainable through materials and equipment that are locally available?
- within the grasp of pupils at their level of cognitive development?
- a basis for further science learning?
- perceived by the students and community as valuable in the world beyond school?

Decisions need to be made also about the balance that is appropriate between the aspects of science, technology, society and personal development, and about "starting points" in the development of content. For example, development that begins with the science and then proceeds to applications and social aspects is likely to emphasize the relationship that the science ideas have to each other, whereas one which begins with a community issue and looks to science and technology as part of the solution is likely to emphasize the relationship of the science ideas to applications and human purposes. This discussion is taken up in detail in Chapter Four.

3.4 Balancing National, Local and Individual Needs

In the current interpretation of *Science for All*, the curriculum must meet national, local and individual needs. National needs are expressed through national policies and programmes, for example, in agriculture, technological development, conservation and "basic needs". Local needs arise from the community and local environment. Individual needs arise from the purposes, aspirations and daily lives of the students.

It is necessary to specify how the curriculum will provide for common learnings across schools and also for unique learnings in a particular locality.

The options available include the following:

- *A national "core plus options"*. This might be achieved through a given number of units of core and other units to be selected at the local level. An alternative, with less flexibility, is that core units run all year and each unit has an option component to suit different localities. In this model, the options are developed centrally by writing groups who visit different regions of the state, explore the region and consult the local people.
- *A "national core" plus "local options"*. This model is like the one above, but the options are developed at the local level, probably at the level of the individual school. It is possible to build into the model ways of accrediting local units if this is required.
- *"School-based curriculum according to Government Guidelines"*. The responsibility for curriculum development rests with the school. The Government provides guidance on the purposes, approaches to, and general content of the curriculum. The level of detail in the guidelines has to be chosen to provide a balance between Government and school control over the curriculum actually provided. In a decentralized model like this, a large proportion of assessment also is school-based.

A strongly centralized approach to curriculum [often called a "Research, Develop, Disseminate" (RD&D) approach] cannot of itself meet local and individual needs. It can produce highly polished programme materials and equipment and disseminate them to all schools quickly. It has to be coupled with extensive training programmes and support for teachers to achieve effective implementation.

The RD&D model reached the peak of its application in the major programmes in the USA (PSSC, BSCS etc.) in the 1960s. Extensive research has been done since then on their achievements. In spite of the vast resources given to development, training and implementation, the programmes fell far short of national expectations. Even committed teachers often took 5-8 years before they could use the materials as expected. By their nature, the materials and teachers' guides could not identify and respond to local needs and resources or individual students.

Many countries have explored variations on the RD&D approach which put the curriculum into closer contact with local needs and allow a component of local curriculum. In Thailand, the Institute for the Promotion of Teaching Science and Technology (IPST) develops complete curricula which schools are encouraged to adapt to meet local needs. Indonesia allows a 20% local/regional component of the curriculum. In India, the National Council of Educational Research and Training prepares 'model curricula' and supporting materials. The curricula are not compulsory. Various state boards of education or certain examining boards modify the materials according to their needs.

"School based curriculum development according to Government guidelines" supports the development of curricula which suit local students and their community. This approach is being carried out in the state of Victoria, Australia. It builds in a partnership between teachers, parents, students, local community and national government. It places responsibility for development and implementation with the school so that, even though the ostensible quality of the materials may be less than in the centralized case, the quality of implementation and the linkage to the lives of the student is much higher. Once again, strong in-service education and systems of support for schools are required, so that teachers and the community understand the guidelines and have the skills to work with them in creative ways. Without this support, some teachers use their "freedom" to teach the same old things in the same old ways.

Lines of accountability and systems of reporting have to be established, to ensure adequate accountability to each of national needs, local and individual needs. This requires clear conception of the balance of central and local responsibility and the mechanisms by which each responsibility is monitored.

The skills required of the teacher are different from those required in curricula designed in detail at the national level. In the latter case, the essential task of the teacher is to implement the curricula as described in the text books and teachers' guides. If there is a local component, teachers must have also skills in curriculum development, including abilities to work cooperatively with other teachers and the community.

3.5 Structures and Processes for Curriculum Management

Successful implementation of educational change requires an efficient mechanism of curriculum management.

It is necessary to establish a communication network, structures and procedures involving governments (national, state/province, and district), schools and communities.

The roles and responsibilities of each government body, administrative unit, schools and the community will vary according to the overall strategy of curriculum development and implementation. In particular, they will depend on the extent to which the management is centralized.

The tasks for which responsibilities need to be assigned and administrative structures established include:

- developing curriculum policies and guidelines
- reviewing current curricula and resources in the school and community and gathering information on local needs
- planning for educational change at the school and system levels
- developing syllabi and teaching aids
- preparing guides and support materials for teachers
- preparing textbooks and student materials
- preparing science equipment, kits and audio-visual aids
- training teachers, advisers and inspectors
- developing instruments of educational measurement/assessment
- disseminating and communicating policies and materials to schools, community, commercial publishers, and others
- evaluating the quality of the curriculum and its implementation
- training teachers (in-service and pre-service).

The ways that these tasks are achieved in a decentralized system are very different from a centralized system. For example, if schools have a major responsibility for curriculum development, the responsibilities of district advisers include assisting principals and senior staff with school management, assisting teachers to understand general policies and develop curricula, and assisting the community to be involved in curriculum planning. Alternatively, in a centralized approach, the adviser supports dissemination of the materials and assists teachers to understand and use them effectively. As a second example, policy development is almost entirely a central responsibility in a centralized approach, but schools as well as the central agency must develop curriculum policies in a school-based approach.

The establishment of science and mathematics curriculum development centres such as IPST in Thailand and ISMED (Institute for Science and Mathematics Education Development) in the Philippines, shifted the responsibility of curriculum development from the state to these centres. Teachers and subject specialists can be seconded to these centres to assist the curriculum design team and the editorial committees in all aspects of the work, from curriculum design to the production of teaching materials. The centre's job is not over after developing the curriculum and materials. It also conducts field trials, ascertains research findings and utilizes these for renewal at regular intervals. Mechanisms for passing such findings back to the teacher must be well developed, so that the teacher is constantly updated in all aspects of his/her work. Development of activities and experiments is a major aspect in the universalization of science and technology education. Some of the centres have established instrumentation laboratories/workshops or are linked to other centres for the development of laboratory equipment. The teams here develop manuals and laboratory guides. They also suggest how modifications and alterations can be effected in local situations.

While the choice of approach will be governed by specific situations and availability of expertise, the point that needs constant emphasis is the involvement of teachers. Their association with the development stage is crucial for success at the implementation stage. It gives them self assurance and a sense of involvement.

3.6 General Strategies of Change

Extensive research has been done over the last two decades on educational change and its management. (See for example, Caldwell B., Beare, H. and Millikin, R., *Creating an Excellent School*, Falmer Press, London, 1989; Sergiovanni, T., *The Principalship: A Reflective Practice Perspective*, Allyn and Bacon, Boston 1987; Fullen, M.F., *The Meaning of Educational Change*, New York, Teachers College Press, 1982; Miles, M.B. and Louis, K.S., "Managing large scale change in urban high schools: how to get there", *Knowledge in Society*, 1989).

The success of educational change is greater if we "Start from where we are, think big, and move forward in small steps".

If "thinking big" means moving the curriculum towards an Science, Technology, Society, Personal Development (STSP) approach to *Science For All*, strategic options include the following actions:

- Identify content in the present curriculum which could be used to learn science concepts related to technology in the society. Illustrate these processes through adequate examples of application in everyday life.
- Identify situations from the local community which can be applied to various themes in the existing curriculum. Establish training programmes for teachers, and assist them at the local level to understand "Science for All" and make appropriate inclusions in the curriculum.
- Choose topics for the central curriculum such as sanitation, environment, pollution, global warming that relate to local, national and global issues. Design projects for the children through which they develop skills of problem solving, cooperation, applying value judgements in the context of improving the quality of the society they live in.

"Starting from where you are" requires analysis of the current situation. The analysis should consider not only current structures and current practice, but also resources, trends and emerging needs.

The development of central curriculum guidelines might involve analyses by experts from different backgrounds such as education, agriculture, industry, health and social justice. Alternatively a steering committee might be established with representation from parents, teachers, unions, government, academia and industry. The steering committee might conduct some parts of the review itself and commission other parts.

Research work may need to be carried out. For example, Indonesia conducted a nationwide study of the cognitive development of students in the targeted age range; India gathered data on the needs, motivations, and backgrounds of teachers and students; Philippines completed socio-anthropological research to develop the basis for a needs-based curriculum.

The depth and time required for the preparatory stage depends on the extent of the changes envisaged. For example, major changes to school and curriculum structures, teaching approaches, and assessment at Years 11 and 12 in Victoria, Australia began with the establishment of the Committee of Review in 1984 and led to changes which will operate fully for the first time in 1992. Throughout that period, there has been major discussion of the issues, plans and curriculum designs at all levels of the community, including parliament, educational groups, industry, the public media, schools, parents and students.

Researchers like Matthew Miles consider educational change in stages. The first stage Miles calls *mobilization*, the second *implementation* , and the third *institutionalization*. Institutionalization is the process of embedding the change into life of the school so that it is able to survive changes in leadership or challenges from reactionary groups.

The stages are useful in spite of the facts that they overlap and they seldom occur in simple sequence, because strategies that are especially effective in one stage are not necessarily the ones that are most effective in another stage. For example, mobilization can be led by a small group in a top down way, but implementation cannot occur unless there is wide commitment to the change and wide ownership of the implementation strategy.

Sergiovanni talks about schools being "management loose, culture tight": teachers are loosely bound in the management sense, often making decisions of their own in their classrooms and when planning and conducting their work. On the other hand, they are strongly bound in the cultural sense of having a common view of what "good education" looks like, what "good curriculum" contains and how "good teachers" work. Educational change needs to address the "culture" of education rather than simply work with administrative controls and demands.

Achieving community involvement in the change and community acceptance of the new curriculum needs to be planned. It might involve wide participation in the Review stage, as mentioned earlier. It might involve advertising campaigns and public meetings, videos and explanatory brochures. Opinion leaders, community leaders and parents must be reached. Government offices, private industry, publishers and voluntary organizations must also be involved so that they can assist in guiding and achieving the changes, and perhaps help in the production of materials and equipment.

Mobilization of the whole of society to support an innovation inevitably results in a feedback from all levels. Provision must be made for this feedback to be received, evaluated and used.

3.7 Teacher Education and School Support

The real worth of any curriculum development depends finally on the manner in which it is transacted in the classroom. Quality of learning and social justice depend ultimately on the teacher. Teachers have the moral responsibility of performing the job set for them by the entire cast of policy makers and curriculum designers, head teachers, parents, children, community and colleagues. Everyone expects their own thoughts, expectations, ideas and philosophy to be put into practice.

All teaching staff must understand the changes that are planned and be reasonably committed to them. Teachers who will be directly involved in the implementation must develop the knowledge and skills require – whether in curriculum development (in a school-based strategy) or use of particular materials and equipment (in a centralized approach).

Teacher preparation was often inadequate and underrated in attempts at curriculum change through the 1960s and 1970s. For example science kits were distributed in several developing countries with little attention to advance preparation of teachers or in-service education. In the majority of classrooms, the kits were not even opened let alone used regularly.

Similarly, attempts to keep teachers informed and supported are often inadequate. A teacher may not receive an educational bulletin or brochure, or its importance and meaning may be lost because no-one is discussing it with the teacher. Solutions include the establishment of "expert groups" to receive teachers' problems and offer solutions, district "school support centres" and consultancy services, "team approaches" in schools where there are a number of teachers, "networks" of teachers across schools in a district, and professional associations at the state or national level.

Although the head teacher may not be directly involved with the teaching of the new curriculum, he/she must understand it and its relation to the whole curriculum and the operation of the school. Successful implementation requires the support of the school administration and indeed all levels of school support within the Ministry. In-service education programmes are required for teachers and for school administrators. Programmes for school administrators need to address curriculum directions and also processes of management and change.

Training in the use of central policy documents or curriculum materials can be of two kinds. The curriculum developers might train teachers directly in face-to-face encounters. When the teaching force is large and direct training is prohibitive, trainers or consultants have to be recruited and sent out to work with teachers. Distortion of the original idea is likely in the second case, because of the stages in the communication. For this and other reasons, training should not be a "one off" event. The meaning and implications of an innovation become clear to the teacher over time, when he/she is working with it in the classroom. Support should be on-going.

Teacher training must equip the teachers to handle confidently all aspects of the curriculum, including content, teaching methods, development of local curriculum, community involvement, student assessment and programme evaluation.

In-service education for head-teachers, school administrators and members of the local community who work with the school needs to be planned and conducted just as thoroughly as in-service education for classroom teachers. This is so especially when the school is large and where it has considerable responsibility for curriculum development.

If the school rather than the state has responsibility for designing syllabi and work programmes, coherence and continuity of curriculum must be achieved at school level. Planning and curriculum development need to involve all teachers. If the curriculum is to reflect the needs of the local community and the role of parents in the education of their children, then parents and the community must be involved in the development. If the school is large, formal structures are required for curriculum planning, school management, and professional development.

Colleges of education and teacher education can play a very effective role in assisting with in-service training, curriculum development, and on-going support.

3.8 Evaluation for Quality Improvement

Evaluation should be an integral part of all stages of educational innovation:

- planning (assessing needs, trends, pressures, administrative structures and resources; setting goals and deciding strategies);
- development (designing policies, structures, programmes and/or materials; trialing draft materials);
- implementation (staffing, training, enacting);
- review

Evaluation is an important part of planning and development. It is important also in the accountability of schools, curriculum units and individuals to government and community. It affects decisions about programmes and individuals. Accordingly it has a political component alongside its objective value in supporting decision-making.

Evaluation needs to be systematic, and it needs to be planned and funded as part of educational change.

At the classroom level, teachers have a central role in evaluation of their teaching programmes and the curriculum materials they use. They need to be trained in advance. Part of their training should be to help them use others – especially students, other teachers, inspectors and consultants, parents, and the community – as part of the evaluation. Assessment of teacher performance must be carried out in a non-threatening manner. It must be seen by the teachers as an aid to improving their professional competence.

The evaluation of published materials during their development should also involve teachers as well as curriculum developers and academics. Many countries, such as Thailand, have carried out small scale trials of books and equipment. Such trials enable the materials to be modified and improved before mass production, but do not preclude other evaluations at a later date.

In addition to the teachers assessing students' and their own performances, education authorities must monitor the implementation and achievements of the curriculum nationwide. The plan should address all aspects of the curriculum, not just teacher performance and student achievement. It should investigate the whole management structure in order to ascertain whether the communication system allows the complete flow of information back and forth between school authorities and classroom teachers, at all levels, and whether the systems of school support, facilities development, teacher education, review and planning etc are adequate.

The plan is likely to involve various institutions, such as research organizations, and teacher training institutions, and special administrative units within the Ministry, such as an inspectorate or research and evaluation team. It must also involve all units in evaluation of their own functioning and the performance of units around them.

Chapter Two

Implications for Teacher Training and Orientation of Other Education Personnel, the Community and Parents

The Science-Technology-Society-Personal Development approach (STSP) gives new emphasis to the centrality of the teacher in science education and to cooperation between teachers, parents and the community.

Teachers roles in curriculum design, school management and community interaction are extended in comparison with traditional teaching. Wider subject knowledge and a broader range of teaching skills are also required. Hence professional development and systems of professional support for teachers become critical elements.

The chapter offers guidance under three headings: the professional development of teachers, interactions with parents, other personnel and the local community, and supporting system for teacher improvement.

1. The Professional Development of Teachers

The 1960s approach to curriculum, with its student books, kits, equipment, films, teachers' guides and training programmes was described at the time as the "teacher proof curriculum". The materials kits and guides were seen as the keys to success, as long as the teacher followed the teachers' guide faithfully.

Parents and the local community were peripheral. The curriculum and materials were designed by experts at the national level. The curriculum was intended to be implemented in the same way to all children in all localities.

The strategy was consistent with the learning theories, ideas of social justice, and approaches to management that prevailed at that time.

The Science-Technology-Society-Personal Development approach is very different: constructivist learning theories, participative management, and a view of social justice that has moved away from "equal treatment of all children in all localities" to concern for local and individual variations in purpose and learning style.

The teachers' role becomes pivotal:

- The curriculum has to meet the needs and backgrounds of individual students. The teacher has to be a curriculum designer.
- The student's background and hopes are significant parts of his/her learning and are largely matters of family life. The teacher needs to work with parents to ensure that education at home and school reinforce rather than contradict each other.
- The curriculum should have a local component, linking to the life and problems that belong to the student – the environment, experience, and people of the local community. The partnership between school and community can extend to curriculum implementation as well as design. The teacher needs skills to work effectively with the local community.
- Science knowledge has to be hooked up to applications, problem solving, technological design, social and environmental issues and local questions of quality of life. It has to provide opportunities for students' personal development, assisting them to refine and build their world views, and develop skills in solving real-life problems, expressing themselves, taking effective action, etc. Education has an orientation to individual development as well as social development. Teachers need broader knowledge and a greater range of classroom skills than in traditional programmes.

The load on the teacher must be shared. Sharing the work and the responsibility supports the teacher. It also ensures that teachers, parents and community have a common view of the goals and methods of the curriculum, and the way that the local and national components fit together. No longer does the teacher work alone in his/her classroom with centrally provided materials, kits and instructions.

If the teacher is working with others in programme development, policy, and implementation, there must be in the school an infrastructure and management expertise to support it. If teachers are to be creative in curriculum design and teaching, the organizational climate in which they work should be both demanding and encouraging. This depends on school management. It also depends on the esteem with which teachers are held by the community generally.

1.1 The Teacher As Learner

Teacher education occurs whenever teachers develop new knowledge and skills, gain new insights into themselves, their work and their students, create meaning from their experience, revise and extend their worldviews. It doesn't happen only in formal settings and course work: it is a part of day to day experience, imagination and reflection.

Teacher education has characteristics similar to education for children, as discussed in Chapter 1. The constructivist learning described there can be rewritten for teacher education:

- Teachers bring to the teacher education situation their own belief about education: what education is, how children learn, what the children should be taught, what a good lesson looks like, how a good teacher behaves. Their beliefs are often strongly held and little affected by simple instruction.
- They have their own views of themselves as learners, their own strategies as learners and problem solvers, their own interests and educational purposes.

Presented with educational theories and curricular approaches contrary to their own beliefs:

- Some become confused, recognizing shortcomings in their own views, but unable to make sense of the contrary views.
- Some ignore the new approaches.
- Some "misinterpret" the new approaches, adapting them or using parts of them to reinforce their own views.
- Some modify their earlier views and explore enthusiastically the ones presented.

Good teacher education therefore has the following characteristics:

- It begins from the knowledge, interests and beliefs that the teachers (or student teachers) have. The first step must disclose and clarify these beliefs.
- It challenges teachers to extend and revise their existing beliefs and skills. This development is not a simple yes/no step. It is a progression with different teachers progressing at different rates and with "wrong turns" a natural and essential part of the process.
- It takes time, and opportunities throughout the process for further interaction, challenge, and coaching. It is enhanced by group work and peer support.
- It links theory with practice, and makes clear the purposes and value of the learning.
- It employs a variety of teaching strategies, according to the range of programme objectives and the learning styles of the teachers.

There is a second perspective of "Teacher as Learner" : the teacher must have a love of learning as a lifelong activity and must be able to demonstrate good learning strategies to his/her students. These strategies include preparedness to change and explore, open-mindedness, thoroughness, and self-evaluation.

The table in Fig 1 indicates a progression in the roles of teacher and learner that have occurred in the recent past as we have moved towards giving the learner more responsibility for his/her own learning. It applies to a view of the teacher as learner.

Fig 1: Progression in encouraging independent learning.
In the table, 'I' am the instructor, 'You' are the learner.

i. Knowledge based	:	I give, you receive, I test
ii. Knowledge plus extension	:	I give knowledge and suggest extensions; you receive from me, then from other sources; I test.
iii. Problem plus resources	:	I set the problem and provide the resources to solve it, you do it; I evaluate your ability.
iv. Open problem	:	I identify the problem; you find the resources and solve it with my help; we evaluate, you evaluate.
v. Your problem	:	I give experience; you identify the problem; you solve it with my help; we evaluate, you evaluate.
vi. Your context	:	You choose the issue, you define the problem; you solve it (with help); you evaluate.

1.2 Competencies and Roles of Science Teachers

The basic objective of science teaching is to improve the quality of life for all students and for society. The Workshop listed roles and competencies expected of teachers in the STSP approach:

Competencies:

Pedagogical/Classroom Skills: Improvisation; teaching processes; meeting specific needs; handling equipment; assessing; relating science technology to real life; classroom management; managing the learning environment; developing curricula; communicating with students; selecting from and using a wide variety of teaching techniques.

Personal/Professional Skills: Decision making; working with the community to develop curricula and resources; managing the school; communicating within the school system and with the community; questioning; being critical; seeking solutions; evaluating the programme.

Roles

Innovator; developer and implementer of the curriculum; evaluator of learning outcomes; motivator; facilitator of learning; perceiver of children's needs developments; resource manager; communicator of concepts; demonstrator; mediator (for imparting knowledge); interpreter (technological developments); resource of information; community helper/explainer; learner of science and technology developments; theoretician; coach; supervisor; model; designer of activities; coordinator.

These roles can be summarized under headings:

- curriculum developer
- evaluator
- learner
- resource mobilizer
- communicator of change in school and community
- motivator
- innovator
- participant in the total functioning of the school

1.3 Pre-service Education

The ideas about education, science, and themselves as teachers that trainees bring to their pre-service course have been acquired mainly from their own experience at school. Their views may be held quite strongly: their propensity will be to teach as they were taught. They come also with a strong sense of purpose, a mission to become good teachers. They have chosen to be teachers.

Consideration of Content

The programme needs to include studies of the science related to the school curriculum. The definition of science needs to include all the aspects that are part of school science: applications, social context, philosophical ideas and social/personal action as well as science knowledge and processes of inquiry.

Trainees need to understand the psychological and philosophical foundations of education, especially the nature of children's learning and the strategies children use to learn.

In addition, teachers have to be aware of educational policies related to the curriculum, socio-economic programmes, technological advances and needs, and have insights into social structures at the state/national level and at the local/village level. These define the context in which education occurs.

Trainees should begin to develop the pedagogical and professional skills listed earlier.

'Value' orientations for developing personal or professional skills have to be addressed. These include 'sensitiveness' to the society for better cooperation through negotiation within the school and communities; achieving personal satisfaction through teaching, observing and enjoying children; and interest in science and being 'scientific'.

A teacher is a model of scholarship and fairness for children and the local community. The teacher needs to be a professional. The teacher must have leadership skills and personal skills to make learning a lively and enjoyable experience for children. The teacher must love learning and demonstrate good learning strategies to his/her students. The teacher must be prepared to change and explore, be open-minded, thorough, and self-critical.

Student Teachers Working with the Community: An Example from India

Working with the community was a required component of the teacher training programme. It was expected to benefit the community as well as the student teachers.

Faculty and trainees discussed possible areas for work. Their list included hospitals, urban slums, rural housing, the School for the Blind, Institutions for the Physically Handicapped, and polluted areas.

The trainees chose a work area and were formed into groups of fifteen or so according to their choice. It was expected that visits should occur weekly, last about three hours and continue throughout the year. Normally a faculty member would accompany the group.

The first visit brought a wide range of reactions from both the trainees and the institutions they visited. Hospital authorities were unwilling to be involved. Organizations working with urban slums and rural housing said no. The School for the Blind and the Institute for Mentally and Physically Handicapped welcomed the involvement. In polluted areas, even where there were voluntary groups already working, more were needed.

Many of the trainees coming from rural areas, although initially hesitant, became excited about the possibilities. In general, trainees from urban areas were less keen.

The different areas held different attractions to the trainees. There was particular enthusiasm for working with the physically and mentally disabled. The experiences of that group are highlighted below.

Working with the disabled

Education of the disabled is part of the formal lecture programme. The visits were seen by the trainees as complementing the formal programme. The group also received regular informal guidance from faculty members.

In evaluating the visits, the trainees and staff in the programme noted:

- The trainees' social sensitivity in general was enhanced and they felt that the visits would have long term value in their careers.
- The children grew in self confidence. They enjoyed the trainees' visits.
- The interaction helped the trainees to understand the capabilities of disabled persons and the nature of disability. The trainees developed positive attitudes towards the disabled. Misconceptions were removed.
- Only some portions of the formal lecture programme was useful in the practical situation. At the end of the year, the trainees reports of their experiences were passed on to the faculty, as an input to curriculum improvement.
- Techniques for handling disabled children are best learned by actual practice.
- Several members of the group were upset by their first experience working with disabled persons in the institution. They had to be supported, prepared and helped to understand the need before they could proceed effectively.

1.4 In-service Education

Practising teachers come to teacher education programmes with knowledge and experience very different from pre-service teachers. They have direct knowledge of children, schools and teaching, and opportunities to practise new skills and ideas immediately. On the other hand, they may be more set in their ways and sceptical of new ideas. They also face greater difficulties with time constraints and competing responsibilities. The danger with the in-service course becomes "trying to feed too many things in too limited a time".

One of the first steps must be to have the teachers reflect on what happens in their classrooms and evaluate their teaching and the curriculum they offer. They might do this evaluation through reflection and discussion, keeping checklists, talking with students, or having an observer in the school with them. Its purpose is to clarify what already happens in the school, and the teachers' current beliefs about what should happen.

Current practice and the current curriculum need to be challenged, and teachers helped towards "better" solutions. Teachers have to be persuaded that the new approach is better than their current one. Then they must be assisted to understand the new ideas and learn the new skills. This might be achieved in part through argument, but will also need demonstration (whether live or on video), analyses of "good" and "bad" practices, and opportunities to try the new approaches themselves.

In-service courses should address also renewal and extension of knowledge to which the teachers are already committed: new science content, new equipment, management of experiments, assessment, and reporting to parents. This component is oriented not to major change, but helping teachers do better the job they see themselves doing. It is important, even in a programme of "major change". It recognizes and responds to teachers' knowledge of their work and the interests and in-service purposes they see as important.

A third component of in-service education should be oriented to enhancing the teachers' career prospects: assisting them not only to be "better teachers" but to work as coordinators, department heads, curriculum advisers, head teachers. This career component is more important in the STSP approach than the traditional curriculum because of the greater emphasis in STSP on school based curriculum development and involvement of teachers in school management. It is important also because teachers see that the programme designers are looking at the world from the teachers' perspective, and not simply regarding the teachers as technicians who serve the purposes of the curriculum designers. And it is important for the long term development of schools and the school system because it enhances the quality of school leadership.

The success of a curriculum project and the quality of children's learning depend ultimately on the quality of the teachers. Teachers, much more than curriculum materials and broad educational policies, guide and effect social justice in education, because they guide the progress of each child in their care.

Those who teach the teachers must do their work well. They need sound knowledge of the education in the country and must understand and value the problems of the teachers. The language and images that the trainers use must connect with the experience of the teachers. Teachers are not leaky vessels to be topped up from time to time by an in-service programme, and now and again emptied and filled with a "new oil". In-service education programmes should be models of the good practice that the teachers themselves are expected to use: student centred, experiential, challenging current beliefs and competences, and extending them.

Professional development does not only occur during in-service education programmes. It occurs whenever teachers seek, try and implement new approaches. The stimulus might come from students, other teachers, reading, or self-analysis. Teachers need to be assisted with the skills of directing their own learning, and they need support structures and opportunities surrounding them which stimulate their own professional growth.

Teacher Networks

Teacher networks are an important part of professional stimulus and growth. For example, consider the introduction of a new curriculum. As more teachers work with it, the opportunities for them to share their problems and successes increase. Also, individuals emerge who very quickly become successful and creative with it. Hence groups of teachers can be formed, with leaders from among them to facilitate further development. In large schools, the teachers within that school are natural groups, and systems of support can even be formalized within the school. For small schools it is necessary that networks form across schools.

However, it is insufficient to leave these groups to themselves. The groups benefit greatly from "external support" from a consultant, academic, or person involved in the design of the innovation and the conduct of the first phase of training. This involvement also provides opportunities to identify problems the teachers face and give evaluative feedback on the innovation.

Structured courses, workshops and conferences

They can range in duration from half-day programmes to month-long residential courses They need to be carefully planned, according to the principles described in section 1.1, "The Teacher as Learner".

Preparation needs to be thorough so that leaders know what teachers have been doing in their schools and teachers know the purposes and programme of the workshop. It is helpful if the teachers are consulted during the development of the programme.

Workshops and conferences of this kind need to be part of a longer term strategy. There should be follow-up activities — perhaps further workshops, visits by advisers to the schools, or opportunities for participants in the workshop to maintain contact with each other and share further progress.

It is preferable to have a number of teachers from a particular school attend the workshop at once, rather then a single representative. This provides an effective means of support for each teacher implementing the ideas at the school.

An alternative to the "one-shot" workshop is to have a number of sessions separated by periods in which the participants work in schools. Teachers come together for a workshop, then try the ideas over a period of days or weeks in their schools, then come together for a further workshop and discussion, and so on. This approach is better able to use the experiences of the teachers and to support implementation of the workshop ideas.

"Action Research" or Project Approaches

By this strategy, teachers are given much greater responsibility to choose the topic or area of their professional development. They choose the area and design a project which will have direct value in their school, and through which they will develop new knowledge and skills. They might choose a process area (such as activity-based learning, co-operative learning, reducing gender bias in the classroom) or a content area (developing units of work, introducing "quality of life" questions in the curriculum, helping students to be effective learners).

To work well, such projects need to have strong support from the school administration, a good group leader, and support from an outside person (perhaps a curriculum adviser, inspector, or lecturer from a teachers' college).

Examples of Workshop Activities:

Drafting a Unit

1. Work in groups of four people.
2. Choose a topic area which you want to develop. It should be one rich in possibilities and able to be presented over about three weeks of class time.

Topic: Fuel in the Kitchen

3. Brainstorm possible content for the unit. Do this under headings:

   Science: (I wonder....)

   Technology (I want.....)

   Society (Should we.....)

   Personal Development

   Special Experiences.

Try to get a similar number of ideas under each heading. Note the rules of brainstorming: Think laterally. Don't evaluate ideas in the list until the list is complete. Encourage all members of the group to contribute, for example:

Science: Different fuels, heat value, where fuels come from, products of burning, combustion, requirements for efficient burning, heat transfer, the effects of cooking on food....

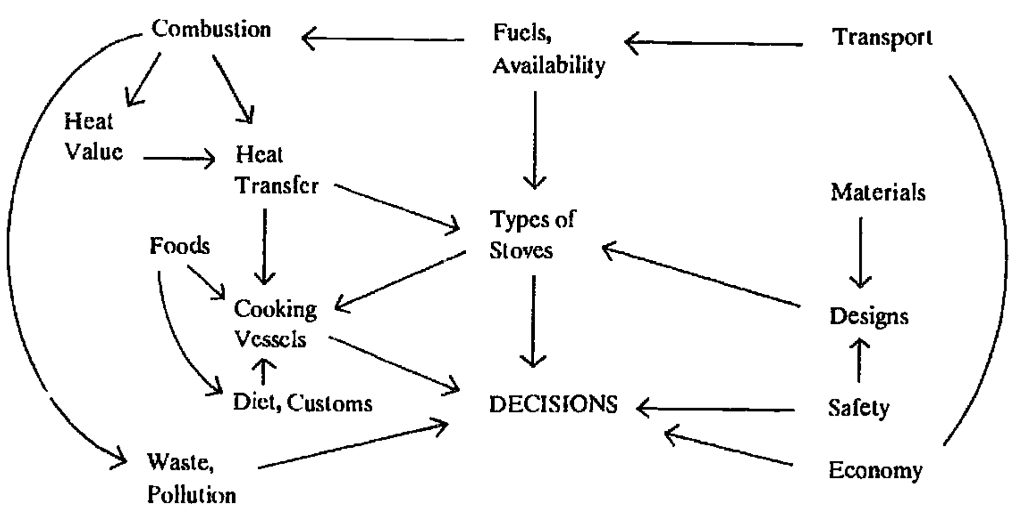
Technology: Types of stoves, designs, choice of materials, efficiency, transport of fuel, cooking vessels, convenience to user...

Society: Environmental considerations: fuel supply, pollution, waste, conservation, economy, safety, health hazards, design, fashion.....

Personal Development: Decision-making, cooperative work, use of time, construction, problem solving, planning skills, researching, values education.....

Special experiences: Cooking with different systems, exploring foods that are cooked in different ways.

4. Draw concept maps or flow charts which show how ideas/activities might fit together.



5. Brainstorm a possible "angle" or theme that will give the unit a sense of story. e.g., an environmental theme, a problem to be solved, a story about heroes, a setting. The angle you choose will give the unit character as well as continuity and coherence, as shown in the following example:

   Improving the efficiency of cooking in the students' own homes, looking especially at fuel use, heat loss/saving, and environmental aspects.

6. Draw a Flow Chart showing how the unit will develop. Think about:

   (a) what the students will do

   (b) what the students will learn

   (c) how well it relates to the children's interests and experience

This may be shown as follows:

Observation of home situation

Students exchange observations

Study of different designs: disadvantages and advantages

Science of fuels and burning

Decision-making of best cooking methods, and improvements to existing methods

Application of decisions individually in the home

Sharing of home experience with community via school

7. Present your flow chart to another group

Drafting Teaching Strategies

1. Work in groups of four.
2. Choose an "untypical" teaching/learning strategy such as: model building, role play, creative writing, drama and dance, hands-on activity, analysis of second-hand data, to use in your unit of work. Teaching strategies would either be small group discussion or presentation of a chart.
3. Develop an activity to go in your unit (from Part 2) that uses the chosen teaching strategy.

   Example: The group discussion will lead to the preparation and presentation of a chart to the whole class. The chart might be like this:

Type of stove	Number of houses using them	Ease of lighting	Cost	Cooking time	Environ. effects
Wood					
Charcoal					
Kerosene					
LPG					
Biogas					
Electric					
Microwave					

4. Run the activity with the group.

Beyond In-service Programmes

Training programmes are only part of the professional development and support of teachers. Staffing and promotions policies, career opportunities, incentive schemes and professional recognition have important influence on teachers' involvement in professional development and successful implementation. Support through consultancy, resource centres, journals, networks and teacher associations need to be available and well coordinated. Lack of finance, teacher time, and unskilled programme leaders are constraints which can hinder the quality of the in-service courses. These aspects were discussed in Chapter One.

2. Interactions with Parents, Other Personnel and the Local Community

The work of teachers is not simply with the curriculum and children. Teachers work within the organizational structure of the school, and the school in turn is linked to the educational system and the community.

Teachers need to know the formal decision-making structures – the arrangements that exist for leadership, control and support in the school; the requirements of protocol and good manners; the expectations of them in the decision-making processes. They also need skills to analyze the formal and informal structures in the school and community, to work effectively within these structures, and to know where they can get help of different kinds by mobilizing these structures.

Some techniques to develop these skills are offered below:

- *Analyze the organizational structures and power relationships within the school and community.* Teachers can be asked to draw organizational charts that show both formal and informal decision-making structures in the school and identify "key people" that might assist with particular changes. Similarly, they can identify people in the community relevant to particular ideas and projects;
- *Work effectively as a participant in decision-making and the development of the school.* Teachers can work in "simulation" exercises, acting as group member or in interaction with a superior. Skills in listening, assertiveness, cooperation and conflict resolution need to be addressed.
- *Prepare arguments and information and present their ideas to decision-makers.* Teachers can practise, with guidance from an instructor, developing submissions to be put to decision-makers. Both written and spoken submissions need to be considered. Part of the exercise can be the evaluation of other submissions. The preparation and presentation of reports should also be considered, whether they be reports to other staff within the school, or to the community, funding agencies or the Ministry.
- *Negotiate with members of the school and the community.* Teachers need skills to negotiate particular changes, and arrange support and co-operation for particular activities. Through modelling, simulation and coaching these skills can be developed.
- *Examine their own skills, behaviours and career goals and consider how these relate to the life of the school and community.* Teachers can make lists of their strengths and weaknesses as participants in the school and its interaction with the community. They can draw maps which show some of their major achievements and interests, and the way these achievements relate to each other in their career development, they can set goals and plan the next steps in their professional activity.

The details of programme objectives, emphasis and interpretation will vary from one country to another according to the culture of the country, the structure of the society and the expectations and roles of teachers. These interpretations need to be worked through in each country. Variations, even within a country, have to be expected, as the education reforms reach the different ethnic and cultural groups and different physical environments.

Other Personnel, Community and Parents

Other education personnel, parents, and community can have significant roles in the development and implementation of new curricula, a school programme, or a class project. Their contribution comes in several ways — cooperation and assistance, giving direction for further improvement, moral and/or financial support, supervision.

The implications for teacher education come in two ways. First, teachers need to have the skills and strategies for working effectively with the other groups. Second, the other groups need "professional development" that orients them to the work of the schools and assists them to work with schools. There is a sense in which they become "teachers" through their involvement in curriculum design, school operations, and the children's learning.

Parents

Parents should be involved in schools and curriculum planning because of the stake they have in their children's education, the knowledge they have of their children's character, hopes and the activities, their involvement in the local community and their insight into the needs and resources of the community. The achievements of schools are greatest when the values and purposes and approach of the schools are in tune with those the child experiences in family life, peer groups, religious observance, and other community activities.

Arrangements can be made for parent involvement in school activities at different levels:

- *Communication:* Parents need to know what the school is trying to achieve, what the children do at school and how their children are progressing. Teachers need to know about each child from the family's perspective and the family's observation of progress and/or difficulties. Effective communication with parents is not easily achieved. Some parents do not read, or read well in the language used at school. Some find schools and the symbols and language of schools daunting, so that a visit to the school, or discussion with a teacher or head teacher is hard for them. A range of approaches have to be used: meetings of parents of children in a particular grade; one-to-one meetings between a teacher and the parents of a child, perhaps with the child present; social events which enable parents to mix with each other and teachers informally; newsletters, perhaps in a number of different languages.

- *Assistance in the functioning of the school:* Helping with excursions or equipment, working bees to improve facilities, the organization and conduct of social activities, assistance in communications programmes, collection of data as part of surveys and programme evaluation.

- *Involvement in curriculum planning and school governance:* Informal involvement through participation in programme evaluation and needs assessments; formal involvement through various planning committees, policy committees, or School Council/School Board.

These three levels of involvement imply different levels of input from parents into the purposes and nature of the curriculum in the school. At the "communications" level, the leadership may still be strongly with teachers. At the "school governance" level, the shared responsibility for curriculum planning is formalized through committees and organizational structures, and the balance of responsibility is set in "terms of reference" and membership for each committee.

There is bound to be conflict at times between parents and school, at least for some parents and some teachers or administrators. The conflict can be between educational values and cultures within the school community, between different views of correct processes in communication and decision-making, and between judgements of right and wrong behaviours/actions — whether of a child, a teacher, a parent or an administrator. Conflict is not necessarily negative. It may be simply an expression of different ways of doing things, and as such, a stimulus for better solutions.

For example, a parent may "guide" the child towards a particular field or future in which the child is not interested, or the parents may want the child to stay home from school to help the family earn its living. The teacher can play a significant role as a "bridge" between parent and child. But it is not clear where the teachers responsibility or right to be involved starts and stops. The following example may be used:

A Learning Workshop for Parents

1. *Did schooling, does schooling do what it should do?*

   Parents recall the society they lived in as children, and the schooling they had. Did schooling exist for them? Did it work for them ? What are their most vivid memories of their teachers and schools? What were the things learned that have been most useful since? How has the world changed over the last 30 years? How different is their education from what it is now?

2. *Learning is simple, or is it?*

   Parents recall a recent situation where they learned something new: using a tool, understanding a situation, etc. They talk to each other about the processes they went through that they thought were important in the success of that learning. Groups attempt to come up with some general statements.

3. *Current approaches to helping children learn*

   A school representative talks to the parents about current approaches to teaching and learning in the school, linking current approaches back to the parents' ideas.

In both pre-service and in-service teacher education, the issues of parent involvement in schooling need to be addressed, and teachers need to be assisted to develop competence in working with parents.

Schools and governments also need to conduct programmes which help parents to understand the roles that they might play in schooling, and develop the skills they need in order to work effectively in schools. Ultimately, their involvement should make a difference to the learning outcomes of children at the school.

Community

The modern concepts of "community and school" and their inter-relationships, the study of community groups, identification of resources and their utilization for the well being of the individual and the community, improvement of the environment, population problems, issues related to local and national development, *Education for All* and *Science for All* as we have described them require strong interaction between school and community.

Community involvement can assist and support the school in curriculum development and planning In this sense it is like parent involvement, improving the school through involvement in the life of the school.

There is a second aspect — the extension of the school into the life of the community. Involvement of the school in the community provides opportunities for the students to link theory to practice, action to reflection; to seek solutions to practical and social problems, to make decisions, to work cooperatively.

Community involvement in schooling and school involvement in the community both require administrative support and programmes of professional development for teachers and members of the community.

Education Personnel

Educational administrators and support persons, whether at the school level (coordinators and head teachers), the district level (supervisors and consultants), or the regional and state levels have critical roles to play in curriculum planning and implementation.

Workshops for School Administrators and Teachers in their Roles in School Management Focus on Planning

Workshops and discussion sessions can be organized on various themes which need to be supported by programmes for the development of skills and strategies. Questions could be raised like:

- What freedom/responsibilites does/do the school have for planning in curriculum? Resource allocation to the school? Resource allocation within the school?
- What areas of operation within the school can benefit from a co-ordinated approach to school planning? Teaching strategies in different classes? School "climate"? Use of resources? Discipline? Reporting to parents? Curriculum development?
- What are some of the major "problems" that the school is facing? How can they benefit from wide involvement in analysis and planning?
- Do members of the school share a vision of what the school's future development might be?

Existing policies and initiatives in the school can be coordinated so as to reflect that vision? Questions that may be raised are as follows:

- What are the steps in the planning process, and what skills do people have for identifying problems, creating solutions, setting goals, and achieving goals?
- What administrative structures and processes exist for making decisions that have wide effect in the school?
- What is the "work climate" like in the school, for teachers, students and administrators? To what extent is the climate sustained in order to encourage the continuing quest for school improvement?

Curriculum innovation is unlikely to make progress in a school if it is not supported by the head teacher and other school administrators. Educational achievement depends on the administrative climate, and the culture of the school, including a sense of shared vision and common direction among the teachers. School management, and the involvement of school administrators in curriculum leadership has much to do with curriculum innovation.

Similarly, district and regional personnel need to have a good understanding of curriculum changes in progress, and of the processes of leadership and change. Supervisors and consultants need special programmes to acquaint them with new techniques, materials, methods, equipment, concepts, management practices, and structural arrangements. They must understand their role in teacher training, including their responsibilities to support teachers and head teachers in the administrative domain. They must be given programmes which help them develop their skills in consultancy, supervision and school support.

A Summary of Roles: Parents, Community and Education Personnel

The following list provides a summary of the roles of education personnel, community and parents in educational innovation. The lists make clear the importance of including parents and community involvement and educational administrative systems as components of teacher education (both pre-service and in-service) and of providing educational programmes for the community, parents and educational administrators to assist them in their curriculum roles.

Education Personnel

Headmasters/Principals

- provide leadership and effective management in school development and the interaction of the school with parents, community and other agencies;
- administer staff, time allotments, resources, and programmes;
- procure materials, equipment and other facilities;
- assist and supervise teachers in their work;
- encourage teachers and students in curricular and extra curricular activities such as science quizzes, fairs, community intervention.

Supervisors, inspectors, consultants

- assist teachers to understand policy, improve their teaching, develop curriculum, and participate in school planning;
- assist head teachers and coordinators within the school to understand administrative approaches and improve their management skills;
- supervise the activities of teachers and schools;
- work with head teachers in identifying problems in facilities, staffing, curriculum and administrative support, and facilitate the flow of requirements within the system;
- organize training courses/seminars/workshops for teachers, parents, community, and educational administrators.

Directors and Superintendents

- give directions (both up and down the administrative system) about changes needed for the improvement of the system;
- provide educational leadership and effective management of support services, staffing provision, resources and facilities in the region;
- implement curricula and professional development programmes;
- administer examinations and programme evaluations;
- recruit and transfer teaching staff,
- make policies at the district, division, and/or regional level such as those related to the upgrading of teachers, providing incentives for teachers, supervision, tasks of headmasters, and activities for students;
- facilitate the procurement of facilities and equipment.

Community

Community Leaders

- provide an environment (peace and order, structural) and services (transportation etc.) that facilitates effective schooling;
- support the school through provision of resources, access to community resources, and assistance of voluntary organizations, volunteers and donors;
- input to curriculum planning to meet local needs.

Organizations/Associations (including Government Organizations)

- support and assist in extra-curricular activities;
- provide facilities and mobilizing manpower for educational activities;
- promote projects which provide professional development for teachers, head teachers, and other education personnel, and for community leaders, parents, and organizations in their roles in education;
- promote education of disabled and disadvantaged people in terms of moral and/or financial support;
- participate in curriculum planning and implementation;
- improve the coordination of their own programmes with school programmes.

Parents

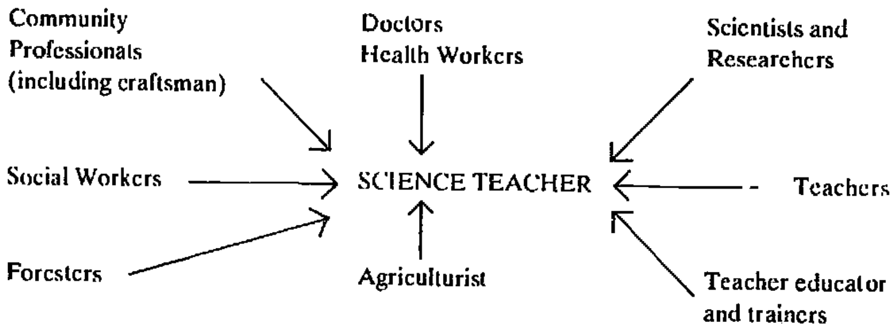
- motivate and support their children, including expenditures in their children's education;
- guide and assist children in their school work;
- provide moral and financial support for the school;
- attend school functions that promote better relationship between parents, child and the teacher;
- accept the responsibilities that they have to understand what the school is trying to do;
- work with the school to improve the children's educational achievements in terms of their perceptions and values on the education of their children;
- be involved in curriculum planning and evaluation of the quality of implementation in the school.

3. Supporting System for Teacher Improvement

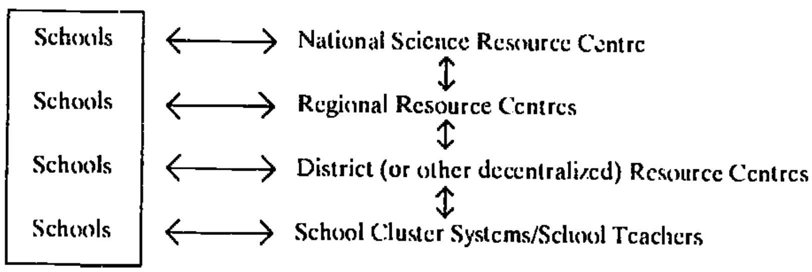
A large number of experiences from different countries are available, which speak of channels and structures available for the improvement of the teacher, and teacher education as a whole.

Inputs through government, voluntary groups and private industry can help science teachers and extend and support the science curriculum. They can provide opportunities for students to see science in the work-place. They can assist students to understand the roles of work in the lives of the individual and society, and develop skills that have value in the workplace.

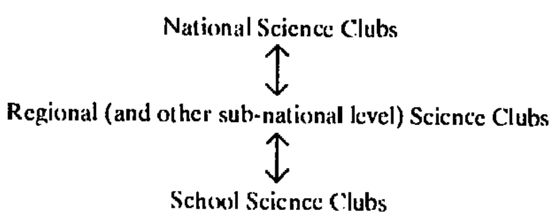
Examples of support systems are indicated on the following page.



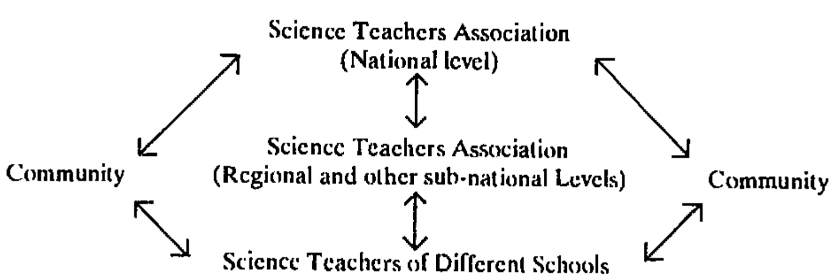
Curriculum developers, teacher educators, consultants, trainers and subject experts may be mobilized though a network of resource centres:



A similar pattern of a networks of science clubs help the teacher in carrying out particularly experiments and activities which involve out-of-school situations.



Voluntary groups of science teachers, through their associations, can enrich the teacher for improving the teaching / learning process through mutual interaction and peer learning, by organizing seminars, training programmes and classroom activities.



The enrichment of science teachers with science knowledge, skills for interacting with children, community and professionals through the above organizational structures could be possible through activities like:

- organizing seminars and workshops;
- talks from community elders, social workers, professionals;
- publishing and disseminating magazines, newsletters;
- updating school libraries;
- upgrading school laboratories and science corners;
- setting up and supporting public libraries and information centres;
- organizing science fairs in schools for the community;
- encouraging projects related to science that deal with problems of the community;
- providing incentives through fellowships and leave for self improvement of science teachers;
- developing children's activities based on the local environment;
- developing test items to be used at school level;
- sharing new information among schools;
- discussing problems encountered in the classroom.

Radio and television programmes on science and technology and their usefulness to society, and answering children and teachers queries can be of gainful use to the science teacher.

In many countries, elements of the above mechanisms already exist. Existing elements may need strengthening and other elements may need to be added.

Of special importance is the gradual development of a knowledge flow system that can respond *rapidly* to changing needs of schools and the curriculum. This includes effective mechanisms to enable teachers in remote and disadvantaged areas to indicate their knowledge reference needs and have those needs met. The increasing opportunities for multiple media, including telecommunications and electronics (compact discs, floppy discs, modems) as well as print should be recognized.

Networks, which currently exist independently can be coordinated and linked into a *holistic* national – regional – sub-regional two-way (user – producer) flow structure. Such a network could incorporate all potential resource generators, including those outside the education system (such as agriculture, forestry, fisheries, health, rural development, small industries, information, broadcasting).

The development of an integrated national knowledge flow system linked into international networks such as UNISIST and ERIC needs to be considered early, so that the compatibility of systems can be ensured. Plans might include translation of foreign materials into the national language(s).

Chapter Three

Application in Real Life Situations: Some Examples

A Model for Evaluating Curriculum Units

Progress in science education over the last 30 years can be considered as development in the three dimensions shown in Fig 2. The three dimensions define a "space" into which curriculum units can be placed according to their treatment of the child as learner, the definition of science, and the extent to which "non-science" is included in the curriculum. Progress has been, in many ways, a move along the diagonal from the "pure science — science as knowledge — child as receiver" corner to the "science/non-science — quality of life — child in community" corner.

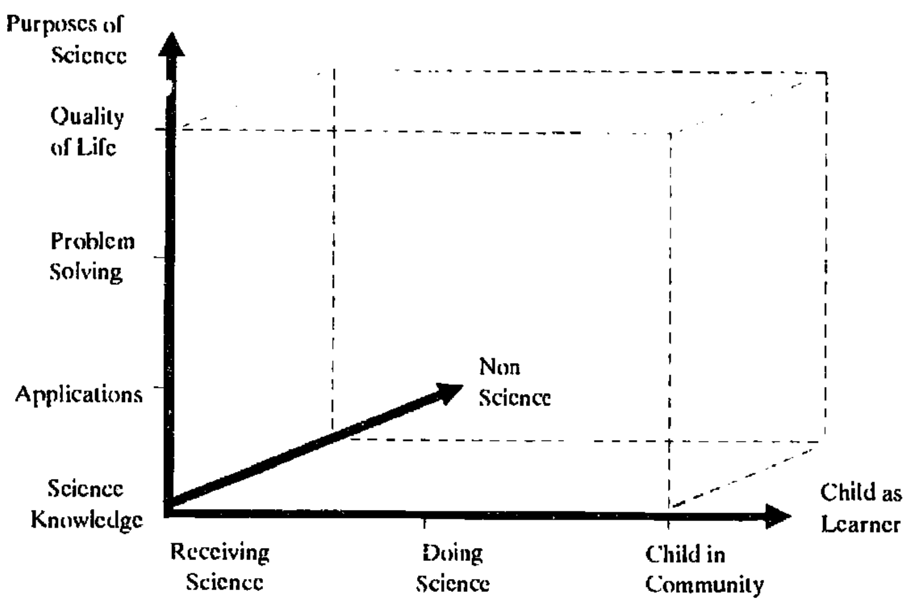


Fig.2 Model for Evaluating Curriculum Units

The first dimension shows different ways of thinking about the child as learner. It progresses from a subject centred approach (with emphasis on the child receiving knowledge), through a "child and science" approach (with emphasis on learning through doing), to a "child in the community" approach (with emphasis on learning in the context of the child's purposes in the local environment).

The second dimension refers to the definition of "science". It progresses from pure science (theoretical concepts and theories and the processes of generating and testing them), to science and its applications in daily life, to science as a means of solving technical problems, to science as a means of personal and community development. It indicates the extent to which human action, values, personal development and quality of life are admitted as components of the science curriculum.

For example, at the science as knowledge end, a lesson might teach levers and the principle of moments. The children would then be tested on whether they can recite the principle and use it to solve set problems. When the approach is extended to applications, students might examine instances of levers in their community. Extended to solving technical problems, a situation might be presented such as lifting a load, where the lever (or a pulley, ramp, or hydraulic jack) is a possible answer. This is a technical problem only, in so far as it has no values component. There is no concern for whether one solution is "better" than the other, only for a machine that is able to do the job. The next extension introduces a values component and raises issues of "quality of life". It might be noted that workers in the village carry baskets of rocks or cement by hand. The students design and discuss some possible solutions, including the science of their operation. A wheel barrow or a conveyer belt system could be provided, but it would cost the owner money, and it might put some workers out of employment. What should be done? Who benefits? What is lost?

"Quality of life" encompasses material well-being (economic development, hygiene, nutrition, shelter, environment). It also includes personal well-being. Personal well-being is the extent to which individuals realize their humaneness. It has spiritual and moral components. It is a measure of the power that individuals have in their lives, through their abilities to think, respect themselves, communicate, feel, take action, participate fully in the life of the community. It concerns the human being both as an individual person whose life is unique, and a social person whose life is shared. At the community level, "quality of life" also raises issues of justice in the distribution and accessibility of "goods" in the society.

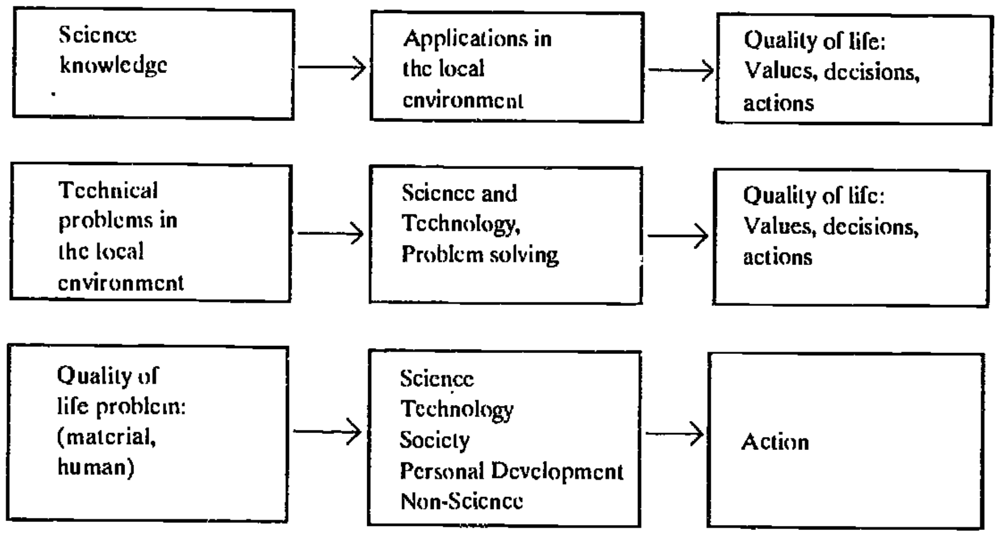
The third dimension indicates the extent to which the science curriculum extends into "non-science" – especially into economics, social studies, culture, politics, environmental education and moral education. The extension is not into formal instruction in, say, economic theory, but rather to recognize that resolution of "quality of life" problems requires consideration of more than the pure science and technology aspects. Setting science in the context of quality of life places science firmly in the service of the general curriculum and the broad purposes of schooling.

The model in Fig. 2 can be used to evaluate a science unit: the unit can be "placed" in the space according to the way it treats the different dimensions.

It can also be used in curriculum design. The curriculum developers can choose a point in the space which they think is most appropriate in their country or school and design the unit accordingly. It is likely that they will choose different points in the space for different units and so create a range of approaches.

The design of a unit depends on how far the developers choose to move towards the "quality of life" corner of the space. It also depends on the way they choose to start the unit, and the subsequent flow of ideas. Three alternatives are shown in Fig. 3. There are many others.

Fig. 3: Different approaches to the flow of ideas.
Each approach is concerned with science and the quality of life



Curriculum Examples:

The examples below are from the various participating countries. They illustrate different approaches to science and its applications in the local community and to the issues of quality of life. They have been analyzed according to the ideas in Fig 2 and Fig 3, to provide the commentaries given with the unit outlines.

The first five examples all address questions of water supply and water quality. They are included because they demonstrate different teaching approaches and emphasis and the range of approaches that can be used to address particular content and purposes.

Example 1: Hand Water Pump

People in our countries use water pumps abundantly. Often they create problems of malfunction, due to leaking, difficulty of operation, water not lifting up, breaking of nuts, or corrosion. There can also be problems with location of the pump, costs, and whether a new bore is required or the pump placed on an existing well. This sequence addresses the first concern: the functioning of the pump. The other concerns are taken up subsequently.

Activity 1

- Ask the students how many of them have a water pump in their own houses and how many of them use the community water pump.
- Ask them to list the problems which are encountered in using and maintaining the pump.
- Indicate that the purpose of the lesson sequence is not only to know more science, but also to contribute to the welfare of the community they live in as responsible citizens.

Activity 2

- Observe and examine the parts of the pump (on site if possible).
- Discussion and learning/teaching (with relevant student activities) on the mechanism and working principles. Student worksheets related to the lever, water pressure, lift and force pumps, should be used for group work, facilitated by the teacher).

Activity 3

- Divide the students into groups with four or five students in each group. (The criterion for selection is that the students live near each other).
- Assign each group to survey four or five houses which are close to their own homes and do the following (Their own homes may be included in the survey):
  1. Interview the people.
     - List any problems they have with water pumps.
     - List ways they try to solve these problems.
  2. Observe the base and the surroundings of the pump.
     - What materials are used to make the base of the pump?
     - Is there a proper drainage system?
     - Is the waste water stagnating near the pump?
     - Are the surroundings clean?

Activity 4

- Ask the students to check the problems which they gathered and make one complete list for the class.
- Discuss the problems and classify them under three headings:
  - Problems they can solve themselves.
  - Problems that can be solved with the help of others.
  - Problems that cannot be solved at present.
- Discuss the validity of the criteria used in the classification, in the context of the real situation in the community.

Activity 5

- Give every student the following learning/practice opportunities with real pumps. Support with diagrams. A technician from the community may help. Alternatives to the parts of the pump may be considered (such as for the washer).
  - Changing the washer.
  - Fixing the nut.
  - Oiling the different parts.
- Discuss and plan for the establishment of a student mobile repair team to help the community.

Activity 6

- Discuss the various effects on people of water stagnating near the pump.
- Discuss how the surroundings of the pump may be improved.
- Plan and take action to improve the surroundings of pumps in the village.

(The local or visit' ̥ Health Officer may help with discussion and planning)

Activity 7

Assign to the students the following as homework.

i) Find out how much water they get in one stroke of the pump. (The students discuss and plan their procedures for this activity)

ii) Is the handle of the pump easy or difficult to operate?

iii) Can a small child (e.g. their younger brother and sister) operate the pump without much efforts or do they need the help of the adults?

iv) Bring to school some water sample in a clean bottle.

Activity 8

Test a sample of water for turbidity, hardness and softness, colour and smell. If possible, test for the pressure of micro-organisms, by sending the sample to a nearby laboratory. Student worksheets are used for this activity, done as group work.

Activity 9

- For homework, students collect information on local methods for improving hardness/turbidity of water. These are presented in class.
- Do activities for removing the hardness & turbidity of water.

(Student worksheets are used for this activity, done as group work).

- Discuss the effect on human beings of micro-organisms, if any, found in water.
- Discuss the methods used for the removal of micro-organisms from the water.

(These could involve expository teaching by the teacher, possibly helped by the local or visiting Health Officers.)

Activity 10

- Ask the students to observe and report the following about the containers which are being used in their own homes for collecting drinking water. Describe the type of container used e.g. plastic, stainless steel, jars made from clay, etc.
- Are the containers washed before each filling? How often? Occasionally, when they look dirty?
- Are the containers covered or kept open?
- What is the condition of the place where the containers are kept, such as dark or lighted, clean or dirty, raised or under the stair case etc.
- Observe and report how water is drawn from the main container into smaller vessels.

Activity 11

Discuss the possible effects or problems that may be created by unclean vessels and containers, uncovered vessels, and the condition of the place where the containers and vessels are kept.

(Assistance may be provided by the local or visiting Health Officer).

Activity 12

- Discuss proper and hygienic ways of cleaning the containers and vessels, and practice using these methods.
- Demonstrate some methods which can be used when drawing the water from the container to small vessels. Students practice these methods also.
- Discuss and plan how the school can help the community improve the storage of safe drinking water.

Commentary

The lesson sequence addresses the following:

- *Social interaction in relation to a technology:* The lift pump is vital to the quality of life of the communities. The lessons raise the values, benefits, customs and social questions as well as looking at the technology.
- *Science concepts:* These are treated in the context of application in relation to levers and water pressure, learned using pupil worksheets, with group discussion facilitated by the teacher.
- *Personal development:* This includes science process skills such as communicating with people, planning for action (e.g. improving the sanitation near the pump area) observation, data collection, inference, etc.

- *Technology:* the repair and maintenance of the water pump; techniques for cleaning vessels to hold water, and for transferring water hygienically.
- *Quality of life:* contributed to from the above, and collective responsibilities for maintaining the quality of life recognized, including social intervention contributions by the students and the school.

Example 2: Danger In The River

The story was developed by a conference group in Kuala Lumpur in 1989. It shows some of the ways that values and ethics can be integrated into science lessons, and ways students can be involved in lesson planning.

Day 1

Ana walked over to her Grade 8 classroom. During the last week, the class had been working on the topic 'Chemical Pollutants'. Halfway through the lesson, she noticed Lee was scratching all over his body. She went over to him and was surprised to see Lee had rashes all over his body. She asked him what caused the rashes. He said he didn't know. He thought it may be something he had eaten. Some students thought it might be that he had brushed against a particular tree. Others thought it was because he had been swimming the night before in the Sunway River. Ana asked the class for evidences for each of these explanations. Lee had not eaten different foods, or been among bushes or insects recently. He had been in the Sunway River. Another student had also developed rashes after swimming in the river.

Lee was later taken to the hospital for treatment.

Day 2

"Are you okay? What did the doctor say?" Lee replied that he had a reaction to chemicals. "Where do you think Lee got into contact with the chemicals?" "It must be from the river!" Sarada answered. Ana thought this was a good opportunity to link what has been taught to a real situation. Ana asked her class whether they would like to spend more time investigating this matter and many agreed.

Ana posed the question "How can we find out what pollutants there are in the river that might have caused Lee's rashes". Soon the class had assembled a list of tasks.

Ana wrote them on the board:

1. Collect water sample from the river.
2. Test the water sample.
3. Search any source that is responsible in polluting the river.
4. Interview local residents to see if the water from the river had created problems to them.

She divided the class into four groups. Groups A and B were to look into matters 1 and 2. Ana would take the leaders of these two groups to the river after school so that testing can be done immediately. Sonya, the lab assistant, agreed to help.

Ana assigned tasks 3 and 4 to Groups C and D respectively. Ana requested Abdul, the chemistry teacher, to guide Groups C and D. The visits to the river and the local residents were to be done outside school hours.

Some students volunteered to go to the library to gather information related to the topic, especially for information on chemicals that might be harmful to humans.

Day 3

The water samples from the river were tested using the techniques that had been learned the week before. Ana was pleased at the level of interest that the students had in their work.

Day 4

Testing of water samples was completed. Ana received the results in written reports. For both Groups A and B the results were similar. Sopie the leader of Group A gave a brief account of what they have done and their findings. They found that the percentage of dissolved oxygen was very low. Sopie noted that this explained the fact why there were not many fishes or aquatic animals in the river. Traces of lead and mercury were also found in the water samples.

"Where did these compounds come from?" Sara asked.

Ana explained, "Before we answer that question we should try to make inferences and conclusions about the findings. Should the compounds be in the river in the first place?" "Definitely not", the children answered. Therefore, we can say that the river is polluted.

Day 5

With the help of Abdul the chemistry teacher, Group 3 reported that they had found a paper factory 5 km. North. "This is probably where the pollutants come from". Further investigations needed to be carried out. For example what are the processes going on in the factory etc. Lee reported that farmers and villagers along the river also emptied refuse and waste into the river. The groups argued that it was unlikely that this waste included mercury and lead. On the other hand, they did not know which chemicals had caused Lee's rashes.

At the same time, Group 4 was having interesting interviews with local residents and employers of the factory. Ana helped them in preparing the interviews and the kind of questions to be asked.

Day 6

From the interviews and investigations, the groups presented some facts and data. It was found that the paper factory was dumping large volumes of chemical waste into the river. Another interesting fact was that almost half of Sunway residents were employers of the factory! Ana posed the question. What action should be taken?

The situation was put on the board:

- River is polluted.
- Factory is polluting the river.
- Factory employs local residents.

The children were eager to give their opinion. To them, the solution was obvious: close down the factory.

Ana pointed out that the problem can be looked at from three different points of view and the implications: the factory owner, factory workers and users of the river. Ana led the class in the discussion and they came up with three options:

1. *Close down the factory*. This implies that the factory owner will lose his business and the workers will lose their jobs.
2. *The owner has to build a proper dumping place or treat the chemical wastes before dumping them into the river.* This will increase the factory's over-head expenses and whether the factory can handle this is yet to be discovered.
3. *Leave it as it is*. Definitely, it affects the users of the river. Lee's rashes was one evidence, lack of fish was another.

Ana was pleased at the end of discussion. Involvement was high and the children had raised good questions. Students were aware of the situation and the difficulties in solving it. They have learnt that they need to be open-minded and willing to accept other people's opinion. She went home thinking about what the next steps for the class might be. She knew that some students wanted to take up the issue with the village factory and with the factory owner.

(From: Values and Ethics in the Science Curriculum,
1989 Workshop Report, UNESCO, in press)

Example 3: Water Pollution and the Growth of Duckweed (an aquatic plant)

Objectives: Upon completion of the unit, students should be able to:

- describe the meaning of water pollution
- describe several causes of water pollution
- identify means to prevent water from being polluted
- take individual responsibility for preventing water pollution

Domestic Wastes:

The teacher leads discussion of waste water from households, to help the students understand the meaning of water pollution, then raises questions about the causes. This provides a lead-in to the activity below.

Activity:

On completion of the activity the students should be able to

- draw conclusions on the effect of concentration of detergent solution on the growth of duckweed;
- describe how domestic wastes can cause water pollution

Time required: 40 mins

Materials: Duckweeds of equal sizes (50)
Feltpen, syringe (25 mL), stirrer, plastic boxes;
Detergent solutions, 0.1%, 0.01%, 0.001%, 0.0001%, tap water. Students will use 20 mL quantities of the detergent solutions

Preparations: Preparations should be done five days in advance.

1. Put stalks of duckweed in a plastic bag containing 500 mL of tapwater.
2. Prepare a 0.1% solution by dissolving 1 gram of detergent in 100 mL of water.
3. Prepare a 0.01% solution by taking 50 mL of the 0.1% solution and adding 450 ml of tapwater.
4. Prepare 0.001% and 0.0001% solutions, using the same logic as in (3)

Instructions to students:

1. Set up 5 plastic boxes, each one with a different detergent solution and one with tapwater. Label each box according to the concentration of detergent in it, including the box containing tapwater.
2. Select 50 stalks of duckweed of the same size. Use a stirrer to transfer 10 stalks to each of the labelled boxes. Arrange the plants so the roots are dipping into the solution.
3. Do not let the boxes dry. Add solutions to their respective containers, as frequent as necessary.
4. Place all four containers in a similar environment: similarly exposed to sunlight, wind, humidity, etc.

Discussion of Results:

The detergent solution of 0.1% caused all the duckweeds to turn yellow and die. The 0.01% solution had no effect on the weeds at the beginning but gradually changed their colour from fresh green to pale yellow. The weeds in the 0.001%, 0.0001% solutions and tapwater grew well. The colour stayed fresh green and some plants grew new leaves. The number of new leaves in the 0.0001% solution was greater than in tapwater. This suggests that large concentrations of detergent are harmful to duckweeds, but very small concentrations may even be helpful.

(The detergent is a phosphate compound. Concentrations of order 15 parts per million help aquatic plants to grow well.)

The effects on other plants can be discussed.

Aquatic plants are useful to the environment. They increase the dissolved oxygen in water through photosynthesis. However, they may cause damage to or impede water flow. In addition, when the plants die, the organic substances which are good nutrients for micro-organisms increase in quantity, and this can pollute the water.

Further Activities:

Similar activities can follow, where students discuss industrial wastes (e.g., high temperature untreated water, toxic substances such as mercury, lead, cadmium, and oil) and then do an experiment where they test the effect of (used) motor oil on Elodea and other aquatic plants. Students can discuss means of removing oil spills, and some of the major accidents that have occurred with oil spills in rivers and at sea.

Commentary

The topic starts from a social problem. The study can lead to an improvement in the quality of life, as students learn some of the effects of water pollution in their community, and ways to reduce them. It also contains the science concepts related to water pollution. Further, the students get opportunity to learn a variety of skills by conducting experiments, discussing and sharing their observations, collecting data and analyzing them.

The topic goes beyond the science concepts. The students are expected to take greater individual responsibility for the prevention of water pollution in their homes and community. This creates a sense of belonging to the community and builds satisfaction and confidence in the students. Such an activity contributes to the personal development of the students and allows them to apply their science knowledge in their real life situation. Science becomes more meaningful for students and gives them opportunity to take part in and make decisions on community development.

Example 4: The Faucet

Water is an important resource which must be conserved. This is the main idea developed in this lesson. The social technological contexts are emphasized. The lesson starts with an activity that presents the social aspects, the community using water, and draws out the attitudes and values of students, raising awareness of the importance of water in their lives. The science aspect of the lesson comes when the water cycle and the sources of water (as ground water and surface water) are discussed. The fact that populations have grown and therefore people have to live further from water sources leads to the problem of obtaining water and distributing it to the users. This is where the technological aspects of the lesson are presented. The water faucet and the water meter are studied to help the students appreciate these technological devices, and develop confidence and a better quality of life through these devices. The necessity for conserving water becomes more evident with the use of the water mete·.

Activity 1: The value of water

Ask students to list ways in which the community uses water. Combine the students ideas into a single list the blackboard and ask students to rate their importance. Ask them to defend their positions. Allow time for discussion if students are divided in their ratings.

Conflicts which arose from students' rating on agreement and disagreement is a clarification activity which enables the students to think of the value of water for them.

Activity 2: How different families use water

Let the students estimate the amount of water their family uses for each activity in one day. Call on 5 - 6 students to fill out a table on the board with estimated averages.

Distribute a worksheet on which they are to record how much water they use in one day, by estimating their water use in different activities. This can be a family activity. Tell them to make a list of the activities that require the use of water, and the amounts ··ed.

If some have difficulty making estimations, give them guidance on the volume of water in a cup, a pail, etc.

Students realize that large amounts of water are consumed in certain activities and the need for water conservation. The data is a basis for discussing issues about lifestyles of people.

Discussion:

Combine the data from different families. Have the students rank the activities from the greatest to the least user of water. Then ask questions like:

- Is the given amount of water used in each activity by each family the same, or is it different? If they differ, what contributed to the difference?
- Could the families use less water for the same purpose? How?
- Would the time of day or month affect the amount of water you used for each activity? Cite examples.
- Ask them to make generalizations from their analysis of the data .

Activity 3: Population and Water Supply

Distribute the UNESCO-UNEP list of 10 worst environmental problems. One of these is the decrease in water supply. These problems arose as a result of increasing demands on finite resources. These demands came from many sources, but the two significant developments which made this problem critical are:

- the rapid escalation of living standards of most of the industrialized countries since 1950;
- the very significant increase in the population of other countries (which have 75% of world population).

Thus, we have 2 kinds of population:

- One that is static in size with increasing consumption of resources (high consuming population).
- One that is increasing in size with increasing consumption of resources (low consuming population).

On the basis of this information, have students explore ideas about the impact of population growth and people's lifestyle on the water supply. Observations and experiences that will come out will be the basis on which students' decisions will be made.

Activity 4: Sources of water

Ask the students about the sources of their water supply and how do they obtain their water from these sources. Discuss the water cycle to show how surface water, ground water and rain water are formed.

The science part of the lesson is presented — water is a natural resource.

Activity 5: The faucet

Show illustrations of the different types of faucet. Ask them to point out the type of faucet they use at home and the different parts of the faucet. Let them explain how the faucets work in their homes. It would be better if you show them actual samples of faucet particularly the screw type. Have at least. one working (actual) model.

The technology aspect of the lesson is developed in this part. Students study the structure of a faucet.

Find out how often they use their faucets each day and what happens to their faucet if not used properly and with constant use. This will lead them to answer that sometimes their faucets leak. Follow up your questioning as to the causes of a leaking faucet and what is to be done about it.

The idea that technology also fails is presented. Knowing the amount of water wasted from a leaking faucet leads the students do certain actions, in this case repairing a leaking faucet.

Ask how many have leaking faucets at home or once had a leaking faucet. Have them find out how much water is wasted from a leaking faucet. Assign those with leaking faucets at home to make measurements. Tell them to set a container under a leaking faucet for one hour. Measure the amount of water they collected. Then multiply the amount by 24 to obtain the amount of water wasted in one day. Let them estimate how much might be lost in the entire village or city.

Activity 6: Repairing a leaking faucet

Ask them if they know how to repair a leaking faucet. Tell them that they will be doing this in the next activity.

This activity is developed to give students self respect and confidence in themselves with the skills and knowledge they gained in this activity.

Distribute a worksheet showing the parts of a faucet and the way to change the washer. Have them to do the activity in groups. Have them also inquire about the cost of getting a plumber to come to fix the faucet.

Activity 7: Water Meters

Students do a survey to see if water meters in their town are all of the same kind. With the help of worksheets they learn to read a water meter and check a water bill.

Students develop confidence can understand the bills they have to pay, and no longer see themselves as being governed by the technology.

Example 5: Green Gunge

The unit is for Year 7 students. Its topic is water purity, separation techniques and conservation. It is told as a story to show how students can be a part of lesson planning and managing their own learning.

Maggie introduced the unit to her class:

"There has been an interruption in the normal supply of water because the School Council has not paid its water rates. The only water available for use in the next month is this 'green gunge' from the local creek". She passed a sample around.

"Why wouldn't you use this water for drinking or washing your hands?" Students complained of the colour, the smell, the floating things and the wriggling things. They also suggested that there would be 'germs' in the water, which they could kill by boiling.

"How else do you suggest we can make it suitable for human use?" Maggie asked. Suggestions were written on the chalkboard.

"Which methods do you think are most likely to work?"

The discussion was lively, and a number of the suggested procedures were modified.

Maggie had each student select a method from the list and try it with a sample of the water. Students talked to each other about their successes and failures. Sometimes their failure was due to limitations in their skill, sometimes because of inappropriateness of their method.

Maggie felt that the students were ready for the discussion on how to develop their skills. She used a flow chart of the unit that she and others of the science staff had worked out. She and the students talked about the work plan and worked out the main goals, how the learning would be organized, and the assessment methods to be used.

Maggie explained to the students that, in their groups, they should assess each others' skills in the particular separation techniques. One of the students was worried about this. Maggie suggested that in order to coach and assess each other effectively, all students should select one of the techniques and become an expert in it. This would help them do a useful job of both teaching the technique to other members of their group, and of assessing their performance.

Skill Development

The textbooks used for Year 7 gave details of a number of separation exercises. Maggie had prepared a worksheet detailing additional techniques. The methods considered were

- sedimentation and decanting;
- filtration (using filter paper, cotton wool, gravel and sand bed);
- flocculation (coagulation of colloid);
- absorption (charcoal filtration); and
- evaporation and distillation.

As the students worked with the skill-development exercises, Maggie led them in developing a list of key words associated with equipment and processes, based on the text and the worksheet. At the end of the section, the students completed a short pen-and-paper test on the basic principles of the different techniques, and their uses.

Purification Projects

Maggie felt that the students were now ready to choose and apply techniques that would succeed in cleaning up the water. She asked them, in their groups, to predict the effects of the different techniques, and to write down their predictions for future reference.

She gave out a worksheet outlining the project, and they went through it together. Each group will be given 100 mL of the "green gunge". Their task is to recover as much clean water as possible. They must decide as a group which technique or combination of techniques they will use. A technique may be used more than once. They must also come to agreement, within their groups, about the ways they will work and the tasks each of them will perform. They should write down their procedure, along with their reasoning. That will help them clarify their plan, and they should inform the teacher of what they are doing. Part of their plan should include record of their work that they will keep: what they have done, what were the effects on the sample, how much water was left, and so on. The teacher will talk to them about their plan when they are ready.

In the earlier exercise on skill development, Maggie had recognized that some groups made quicker progress than others, and these differences had been confirmed in the test. Consequently, she was keen to give the groups considerable freedom to move ahead at their own rates. She invited one group to consider, as well, the viability of their techniques for the larger-scale problem: What if the school really did depend on the creek for water?

Maggie monitored the functioning of the groups, encouraging them to involve all members, and to share both the measuring jobs and the recording jobs. She assessed their work from their ability to plan and implement their procedures, and skill with equipment, as well as their observations and results. Students also assessed their own work, writing brief reports of their achievements.

As the groups completed their analysis, their pure samples were displayed and compared. Two other groups also moved on to the "larger-scale" question, while the remaining groups finished their analyses.

Discussion:

Each group presented the result of these work to the class, outlining their procedures and results. Discussion flowed naturally into consideration of which sample was the purest. Maggie suggested that some contaminants could not be detected by direct observation. She demonstrated the measurement of electrical conductivity and compared the different samples. One of the students suggested that dissolved impurities might be found by evaporating the water, and the groups did water evaporation by setting droplets from their samples on glass slides and left them to dry.

Maggie suggested that the idea of "how pure" depended on what the water would be used for. The class briefly discussed the different demands for washing, watering the garden, cooking and drinking. Some of the students who had considered the larger-scale problem led a discussion of the cost of different techniques. Maggie had provided them with some figures on costs. Many students were disappointed at the cost of distillation: they had considered it to be the "best solution". Maggie suggested that, nevertheless, there might be countries in which distillation was carried out perhaps because of lack of alternatives which justified the cost, or perhaps because solar energy was available for the purpose. Four or five students wanted to follow up this idea: which countries, what methods, how would you design a solar still or solar distillation equipment?

One student remarked that he had seen a film on TV involving "moonshiners", and he wondered if water stills and whisky stills worked in the same way. A third group disregarded this change of direction: if distillation was an expensive method of purifying town water, what action was taken by the town councils and water boards?

THE REST LAID PLANS . . .

Maggie's lesson plan was in disarray, and her unit plan was looking shaky. She called a halt. The class assembled around the chalkboard and listed the questions that had been raised already. Then they added more questions to the list. Based on her original unit plan, Maggie listed the questions in three clusters, relating to: use of water in the home; providing town water; and "individual projects". In the last group came questions from the students and from Maggie's original plan: distillation of sea water and alcohol, solar stills, sewage treatment, provision of clean water in such countries as India and Thailand, finding water in outback Australia, and water diving.

Maggie suggested that the questions which the students had listed under her heading of "individual research" be deferred, and that, in the meantime, half the class might develop a role play on the question of town water, and the other half might investigate water use and water conservation in the home. Both the role play and the water conservation study would complete the "green gunge" story that began the unit; the individual research projects would be extensions of the lessons.

Further Activities

Teacher Maggie offered a scenario for the role play that Con, another teacher, had suggested: "A company wishes to build a factory in our town which will discharge 'green gunge' waste into the river flowing through the town, from which we get our water. The Town Council has to decide whether to issue a building permit. The whole class can play the part of the 'town council', and judge presentations to it by, say, the factory owner, the Chamber of Commerce, the Tourist Association, a local conservation group, and a consulting scientist appointed by the Council. Students can work in three's to develop the presentations to the Council meeting from each of the interest groups. The class will need to talk to some of the people around the town who can help with the arguments. Some contacts have been suggested, perhaps the class can suggest some others ..."

Maggie spent a few minutes explaining what was meant by the Town Council, the Chamber of Commerce, and so on, and discussing with the students the particular interests that the different groups might have.

The water conservation study that Maggie originally had in mind was a speculative problem like: what steps could your family take, if it was obliged to survive on 200 litres of water per day? She needed, now, an exercise equivalent to the role play, and suggested: "The other half of the class can work on a study of water use in the home. It should begin with a survey of the things you use water for and how much is used, say, in one weekend. Students can work in three's to design ways to make the measurements, and to consider their data. The next step will be to suggest ways of reducing water use. Then they can actually put these ideas to their family, try them out for a weekend, and see what reduction they get. The final stage will be to present to the whole class their findings, including the successes and difficulties their family had in reducing its water use for a weekend".

Maggie asked the students to talk about these ideas with each other and with their families before the next class period, and to think about which project they would prefer to do, or how the projects could be improved.

Maggie was pleased as she packed up at the end of the unit: involvement was high, and the students had raised good questions. She was aware that some of the students remained confused about distillation. She would need to help them in a later unit. She was not clear about when the individual projects would start or how she would organize them, and she needed to give some more thought to the group projects. They had taken on a strong social action orientation. "I should go and talk with the social education teachers," she mused. "I probably should have done that earlier..."

(From: Malcolm, C., The Science Framework, Ministry of Education, Victoria, Australia, 1987)

Example 6: Malaria As a Human Disease

Activity 1

The teacher explain with the help of charts and/or audio-visual aids the structure of the mosquito and the life cycle of the malarial parasite.

Objectives: The student should be able to acquire knowledge about:

- Mosquito is a carrier of malaria.
- Structure of a mosquito.
- The life cycle of the Anopheles mosquito.
- The life cycle of the malarial parasite.

Teaching Aids:

- Charts showing parts of the mosquito.
- Charts showing the life cycle of the mosquito.
- Films and video illustrating stages of development of the mosquito.

Activity 2

The teacher arranges for a local health inspector to give a talk about malarial disease, its symptoms, precautions and cure against the disease.

Objective: How to take early action to avoid the disease.

Activity 3

The students conduct a study of the locality and identify breeding places of mosquitoes. With the help of the community these places are destroyed and the spread of malaria was controlled.

Objectives:

- How to get rid of mosquito breeding places.
- Awareness of the importance of cleanliness in school, home, community and environment.
- Taking action to remove mosquito breeding places.

Commentary

The unit starts with presentation of the science knowledge relevant to the malarial mosquito. A resource person from the community is invited to discuss the social issues and assist the student to identify problems that they can address. The students work with the teacher and the community to solve the problem through the application of their knowledge. A further step might have been to explore alternative means of solving the malaria problem, and look at side effects of the different solutions.

Example 7: Electric Energy and Power

The unit explores energy and power in the context of electricity in the home, including the costs of using different appliances, and ways in which electricity bills can be minimized.

1. *Knowledge:* The topic is introduced and the concepts of energy and power discussed, through the equation E = P.t (E is energy, P is power, and t is the time for which the power is applied). Units of kilowatt-hour as well as Joule are discussed.

2. *Application, Community:* Students are asked to survey electric energy consumed by home appliances.

Power (P) of appliances in KW	Time (T) consumed in H (hours)	Energy (E) consumed in KWH	Cost in Rs
100 W Bulb .1 KW	1 H 5 H 10 H	.1 KWH .5 KWH 1.0 KWH	
80 W TV .1 KW	1 H 5 H 10 H	.08 KWH .4 KWH .8 KWH	

Table 1

Month	KWH
January	5677
February	6177
March	6680
April	7180
May	
June	
July	
August	
September	
October	
November	
December	

Subscribing-Card

Rs.5000	February
Rs.50300	March
Rs.5000	April

Receipts

Months	Energy in KWH	Cost in Rs
Jan - Feb	500	50000
Feb - March	503	50300
March - April	500	50000

Table 2

Electric Energy Cost Rs. .... per KWH

3. *Non-Science:* Students count the cost of electric energy per KWH, by using data on a Subscribing - Card (see p. 49, Table 2).

   They use their conclusions to fill in Table 1.

4. *Improving quality of life, actions:* Students make up Table 3 for distribution to families in their community. The students explain the implications of the calculations for the family budget.

How Much Do You Spend for Your Electric Appliances?

Power of the Appliances in W (watts)	Time consumed, in hours	Cost in Rs
100 W	1	10
	6	60
	12	120
	18	180
	24	240
200 W	1	20
	6	120
	12	360
	18	480

Table 3

Commentary

Concept: The concepts of energy and power are taught in the ordinary way, through experiment and discussion.

Application, community: Application in a real life situation is explored, using material at the community level and of importance to the community.

Non-science: Activity extends to economics, to count the electric energy cost per KWH.

Improving quality of life, actions: The student is encouraged to share the findings to improve the quality of community life, and use the skills of explaining and persuading. By knowing Table 3 families can be more economical, because they know the amount of money spent everyday for electrical energy consumption.

Example 8: Measurement in Daily Life

Children learn about the importance of measurement and devices used for measuring mass, length, area, volume, time and temperature. They consider accuracy and approximation, and when precision is needed. They handle measuring devices and use their knowledge of measurement in their interaction with their families and others in their life out of school.

Some of the learning situations are:

- Listing instances where measurement of length, area, volume, time, temperature and mass are involved (market, shopkeeper, tailor, milkman etc);
- Identifying devices used in day-to-day measurements;
- Measurements of mass, length, area, volume, time and temperature;
- Using scales, presenting data in tables and graphs, estimating averages;
- Estimating quantities in everyday situations: the height of a child, tree, building; the mass of a given quantity of sugar, potato, books; area of a room, a table top; volume of a tumbler, teaspoon, cup, matchbox, bucket;
- Finding out the probable causes of errors arising from faulty methods of using measuring devices; finding out methods of accurate measurement.

Example 9: Seeds

Children observe seeds and look for similarities and differences, and think about the uses of seeds for food.

Activity 1

We use seeds as food. The concept that nutritious food is stored within the seed is illustrated through the following questions:

1. How can a seed grow into a tall tree?
2. Which seeds do we eat?
3. Which part of the rice seed can we eat as polished rice? Which part as flour?
4. Which part of the mung seed do we eat mainly?

Activity 2

Compare the seeds of kidney bean and maize. In what ways are they the same? different?

(They are similar in their seed coat and embryo. Among the differences, the kidney bean has no endosperm and 2 cotyledons; the maize seed has an endosperm and one cotyledon).

Activity 3

Plants can be classified as monocotyledons and dicotyledons. List some other plants that you know according to this classification.

Take some other kinds of seeds from home and soak them in water until they are soft. According to the methods you have learned in class, observe their structures and decide whether they are like the kidney bean or the maize seed.

Example 10: Other Examples Linking Science to Everyday Life

10.1 In teaching about the structure of the heart, the class discusses a common heart disease.

10.2 With guidance from teachers, students display at street corners plant specimens they have collected and classified. The students act as little advisers to the public, answering their questions, on uses of the plants.

10.3 Students serve as guides at the National Museum.

10.4 Science Summer Camps provide opportunities for students to learn about the natural environment, cooking, insect and moth control etc. Activities involve learning and applying through play.

10.5 Students in rural areas learn to prune fruit trees, plant vegetables and breed chickens, using scientific techniques.

The examples presented here produces starting points in presenting lessons in science and technology and their effect in quality of life. More examples can be prepared especially those which relate to the environment of the child.

The exemplar cited offer options for the teachers to use in their particular classroom situations.

Part Two

COUNTRY EXPERIENCES AND EXAMPLES OF CURRICULUM IMPLICATIONS OF EMERGING POLICIES

1. Australia

The Context: Education For All

"Education for All" has to be considered at two levels, which will be called formal access and curriculum access. The first is a precondition for the second; both are necessary.

Formal access is satisfied by the provision of schools, teachers, equipment and programmes to all children regardless of where they live, what they believe, and the financial and social circumstances of their families. In Australia, formal access became policy in the 1870s, promising "free secular and compulsory" education for all students up to a given age. Beyond that age (currently 15), education is not compulsory in Australia but it is available and free to Year 12 level.

Curriculum access requires *Education for All* through a curriculum that connects to the experiences and educational purposes of all students. Such a curriculum is not dominated by the interests, values and learning styles of one or another subgroup in the society. It becomes unacceptable to argue that a science curriculum basic for those who will proceed to further study in science is good for everyone. "Basic", like "relevant", is a word that needs to be qualified: basic for what? relevant to whom? If we allow education to serve truly a variety of needs and a range of groups there can be no longer a single definition of "basic".

In turn, "standards" and a "standard curriculum" become hard to define because there is less standardization: Australians in the desert outback have educational needs different from Australian in flats and factories in industrial Melbourne; Australians recently arrived from Vietnam or Greece bring to the learning situation experiences and expectations different from fifth generation Australians in the same classroom. The curriculum must be able to vary from one school to another and one student to another.

On the other hand, there is more to access than providing opportunities for every student to build on his/her experience and purpose. Individuals and their immediate communities are part of the larger society, with its own needs, rules and traditions. *Education for All* has a responsibility to assist individuals to participate fully in society and work for the good of all people. Accordingly there must be an extent to which schools express a common culture and address a common curriculum.

As well as the common learnings necessary for the function of the society, there are certain learnings that have special currency as "gateways" to higher education, employment and economic or personal power in the society. Subjects like Mathematics and Physics are in this category, and skills like rational analysis, problem solving and facility with computers. *Education for All* must ensure that all students have curriculum access to these learnings.

Participation in Science in Australia

At Junior Secondary level, every student studies science, usually for 2.5 - 3 hours per week. Classes are typically 25-30 students. Teachers are qualified with degrees in science and education. Equipment and facilities are provided for laboratory work. Excursions are conducted from time to time into the community, industry, the environment, parks, zoos and museums.

Full participation does not apply outside the band of Years 7-9. In many primary schools, there is little science taught. In Year 10 in some schools (a minority) science becomes an elective. Beyond Year 10 science studies are optional in all schools.

In Years 11 and 12 science is offered as Physics, Chemistry, Biology, Geology, Psychology, Environmental Studies and (General) Science. Physics, Chemistry and Biology command the major share of science enrolments. They are differently attractive to boys and girls. The percentage of girls in Biology is approximately 70%, Chemistry 40% and Physics 25%.

Beyond Year 10, students can leave school. Retention to Year 12 has increased greatly in all Australian states in the last five years (in Victoria it has doubled) and now stands at about 60% of the age cohort. However this growth has not been reflected in enrolments in Physics and Chemistry.

The low participation of girls in Physics and Chemistry and the failure of senior science subjects to reflect the growth of enrolments of secondary schools generally suggest that girls and "non traditional students" do not have curriculum access to senior Physics and Chemistry. Their choosing to withdraw from the physical sciences after Year 10 raises issues about the determinants of choice, including their experience in the junior curriculum. Extensive research has been done on gender bias in the curriculum. It confirms that access is not the same for girls as for boys. Research for other groups, such as gifted children, disabled, and various ethnic groups, has not been as extensive but confirms that curriculum access in junior science is not the same for all students.

Focus on the Victorian Solution

In Australia, education is a state responsibility. While there is considerable similarity between policies and approach in the various states (achieved through the common culture of teachers, Federal Government programmes, and cooperative projects of the national Curriculum Development Centre) there are important variations.

This paper will focus on the policies and approach in Victoria. One state has been chosen so as to communicate the sense of overall strategy that is clear in a single state, but not across states. Further, Victoria's approach is of special interest because of the extent and nature of the current reforms: reforms through the 1980s to provide curriculum access for all students compare in importance to the provision of formal access for all students in the 1870s.

The Victorian strategy was published in 1983-4 in a series of *Ministerial Papers.*

Ministerial Paper 6 addressed curriculum development. The strategy is based on two principles:

- access and success for all students; Education for All
- devolution of curriculum planning and management

Devolution

Schools are responsible for curriculum development "according to government guidelines".

The guidelines express the State's responsibility for the curriculum. They set direction by laying out the purposes of education and principles to guide curriculum development. They provide leadership and coordination.

At the school level, school governance (including curriculum planning) is the responsibility of a School Council comprising teachers, parents and students. At the classroom level, students are involved in setting goals and planning programmes.

Devolution is justified on a number of grounds. It supports the development of curricula which suit the local students and their community. It recognizes the partnership in education between teachers, parents, students and State. It places the responsibilities for curriculum development, implementation and evaluation all with the same administrative group (the school). It enables more creative and quicker response to changes in the educational environment.

Access and Success for All Students

All students are to have access to education that has value for them in the settings and roles in which they operate and in which they expect to operate in the future. As well, all students are to have access to particular ways of learning and areas of learning deemed vital for participation in the life of society.

"Access" requires more than a sign on the door saying "welcome". It requires a curriculum which links effectively to the purposes, lives and abilities of the students who enter.

"Success" is based on a definition of education as growth. It recognizes that students start at different points, and focuses "success" on the increments of learning rather than standard end points of learning. Education is successful if the increments are large, unsuccessful if they are small.

"Success" means that learning makes a difference to the ways students think about the world and the ways they act. An effective curriculum links theory to practice and social purpose, in-school experience to out-of-school experience. It promotes problem solving and cooperative action.

Ministerial Paper 6 specifies areas of learning to which all students should have access. The areas are specified not as a list of subjects, but a list of 32 goals of education. Goals like:

- listen and talk appropriately in a variety of situations....
- understand and apply the basic concepts of number, quantity and space....
- understand the relationship between physical environment, culture and society....
- participate in democratic processes....
- work with tools and materials on practical tasks....
- develop competence with computers....
- understand natural phenomena and the concepts scientist use....
- be aware of the application of science .... and the responsibilities....

In schools, Science teachers have been asked to choose the ten goals to which they feel Science studies can make particular contributions. The distribution obtained is remarkably flat: science can contribute to all 32. The policy challenges curriculum planners in all subject areas to begin planning not from their traditional bodies of knowledge, but from the broad purposes of schooling.

Questions of Implementation

A central issue in the implementation of the *Access and Success* policy has been the existence of two different definitions of education in the community. The two positions are fundamentally incompatible, but use the same terms. There is endless room for confusion and debate.

One view sees education as transmission of a set body of knowledge and skills from teacher or text to students. The knowledge to be transmitted is that which is considered 'essential' for all educated persons of a given age. Students are assumed to be more or less passive receivers of information, with minds that can be cleared of old ideas and filled with new knowledge by the teachers. Assessment is to identify students for whom the transmission has been successful. The content and its sequence are based on the logical structure of knowledge, and, whether inductive or deductive, have the 'big picture' of the knowledge structure clearly in view. To this extent teaching is convergent on 'right answers'. The teacher is the authority of knowledge and management. Education is driven by 'the subject' and the (classroom) management system.

In the *Frameworks* approach, teaching starts from the interests, beliefs, and skills that students bring to the learning situation, and individual differences are accepted and accommodated. Learning is seen as an active process for the students, in which they clarify their own views about a particular phenomenon (probably in discussion with each other and the teacher), have their views challenged, then seek to reconstruct their views in the light of new information. Education is a continuing development, with good education measured by the size of the increments of growth. Students start at different points, move forward to different points, often in different ways. Assessment is geared to diagnosis and progress. It is used to inform teaching and assist students to manage their own learning. The teaching sequence is controlled by the usefulness of ideas in solving problems and seeking meaning rather than by the structure of knowledge. Teaching is often divergent.

The two views of education are profoundly different in their definitions of education, their beliefs about justice, about what science is and what science is worth learning, students and learning, the functions of assessment, the teacher's role, and classroom management.

For example, "success for every child" is possible if success is indicated by growth. It is nonsense if every child must successfully receive the same body of knowledge (no more no less). In the transmission model, a child is "successful" if he/she can demonstrate the required knowledge, but there might have been no growth. Alternatively he/she may demonstrate growth, but still not reach the required end point. What one model claims as "good education" the other rejects. The same applies to justice. In the transmission model, justice requires that all students are taught the same things in more or less the same way; all are given the same test under the same conditions. In the growth model, justice requires that different students are taught and assessed differently according to their starting points and learning styles.

At the same time, neither view of education and learning necessarily invalidates solutions developed under the other, just as Einstein's Mechanics do not necessarily invalidate solutions derived using Newton's. One of the challenges facing the teachers currently is to find better ways of incorporating the things the teachers learned, for example, from behaviourist approaches and learning hierarchies.

Neither is it necessary for individual teachers to change their own position before they take action. Indeed changes in behaviour often precede changes in understanding.

Support for the Policy:

The strategy for implementation of the policy has been a careful one, advancing on a many fronts since 1983.

- *Curriculum Frameworks* were developed in nine subject areas (of which science is one). The *Frameworks* interpret the general policy from the perspective of the subject area, clarify and refine the educational position, and provide illustrations of good practice and advice on implementation. The *Frameworks* were developed simultaneously for all subjects and all grade levels. They reinforce one another, drawing on research and good practice in each subject area from the perspective of "access and success for all". Frameworks in Technology, Mathematics, Social Education and English Language have particular relevance to science.
- Exemplary course outlines and units of work are being published. Many of the units were developed by teachers and teacher-networks in parallel with the development of the *Framework*. A major project is in progress to provide a course outline for Year 7-10, addressing objectives, content, learning experiences and assessment in a fairly detailed way.
- The *School Curriculum and Organization Framework* supports school management and curriculum planning in a decentralized system. It interprets the general policies from a management perspective and provides guidance on administrative structures, management, evaluation and planning. It recognizes the significance of organizational arrangements, facilities, human relationships, school climate, and school-community interaction for the achievement of *Education for All.*
- *Management training programmes are conducted for school principals, curriculum coordinators, and school councillors. There are also regular meetings of school principals with their Regional Managers, to assist in coordination and planning.*
- *Professional development programmes are conducted for teachers. The programmes include teacher networks, conferences, action research in schools, and special courses. As well as after-school programmes and special leave arrangements, schools have eight student free days per year. Neighbourhood schools combine for some of these days, to enhance exchange of ideas across schools in a district. Subject Associations, including the Science Teachers Association, and private consultants also conduct workshops and conferences.*
- *Articles were published in teachers journals and Ministry newspapers to explain and promote the policies, and provide case examples and advice on their implementation.*
- *Consultancy services are provided through district School Support Centres.*
- *Schools must document and report their progress, especially through the reports of school councils to their communities and the Ministry.*
- *Curriculum reforms at years 11 and 12 are in progress, consistent with changes at the lower levels.*

Fig. 1: The Science Platform

The Kind of Science: Science for All

- *All students should study science, and gain value from their studies. The goals, methods and content of science education should provide for the needs and progress of all students.*
- *Science education should be concerned with environmental management, and the survival and quality of life for all.*

Goals: Science, Technology, Society and Personal Development

- *Scientific knowledge, the solution of practical problems, the cultural and human context of science, and opportunities for personal development are four aspects of science. They should be given similar emphasis at all levels of schooling, and should be integrated in their presentation.*

Learning and Teaching: Children's Science Beginning from Children's Perceptions

- *Children (and adults!), by nature, are theorists and problem-solvers, keen to explain and interpret their experiences, to resolve issues they see as important, and to design and build. They bring their perceptions and beliefs to the learning situation.*
- *Children, as experienced problem-solvers, have their own strategies for learning and solving problems.*
- *Science teaching should identify, begin from, and build on the strategies, interests, beliefs and explanations that children bring to the classroom.*

The Role of Teachers: Teacher Development and Curriculum Development

- *The development of both curriculum and teachers' skills in course design and implementation should occur together. Each must be allowed for in planning science education and curriculum revision.*

Curriculum Content: Sampling Scientific Knowledge

- *Any school can only teach a sample of all the knowledge, skills and experiences related to science. The sample should vary from one school to another, depending on local resources, interests and needs. It should include learnings selected from the broad range of scientific disciplines.*
- *Students should truly engage a limited number of ideas rather than seek universal coverage with superficial understanding and application.*
- *Students must have opportunities to feel that they are succeeding, to explore and reflect on their understanding and skills, and use them in a variety of contexts. This takes time, and limits the number of topics that can be covered.*

The Science Framework:

The Science Framework *is, in the first instance, an educational position. The position is consistent with the policy of Access and Success, but drawn from the language and research base of Science Education:* Science for All, Science, Technology Society, Children's Science . *The position is summarized as a "Platform Statement" (Fig. 1)*

The learning theory: Children's Science

The learning theory is "constructivist". Children are seen as serious in their wishes to understand and give meaning to their experience; to refine and extend their world view; to have control over their own lives. They develop theories, beliefs and learning strategies from their lives in school and out of school, and learning is a matter of reconstructing meaning in the light of new experience. There is extensive research evidence to suggest:

- *the beliefs and understandings that children bring to the learning situation are often strongly held and little affected by simple instruction; they are important inputs to the learning situation;*
- *learning strategies can be taught; being smart can be learned;*
- *the range of learning styles, starting points and interests within a group of children and the range of curriculum objectives require a variety of teaching approaches;*
- *learning is enhanced by consonance between inputs from school, home, community, the environment; education is a partnership.*

Science, Technology, Society, Personal Development

The *Framework* advocates equal emphasis for science, technology, society and personal development. The science is theoretical knowledge and the processes of theory building and testing. It answers the question "I wonder...." Technology is the development of artefacts, tools and systems for human purposes. Technology answers the question "I want...." Society is the human context of science; science is a human activity. Personal Development formalizes the opportunities within science classrooms for special experiences (e.g., with nature, machines, animals), and for developing skills in cooperation, personal management, clear thinking, etc.

The *Framework* advocates that science, technology, society and personal development aspects be integrated in their presentation. The entry point is to be sometimes from the Science perspective, sometimes from Technology, sometimes Society and sometimes Personal Development. The choice of entry point is to reflect the "equal emphasis".

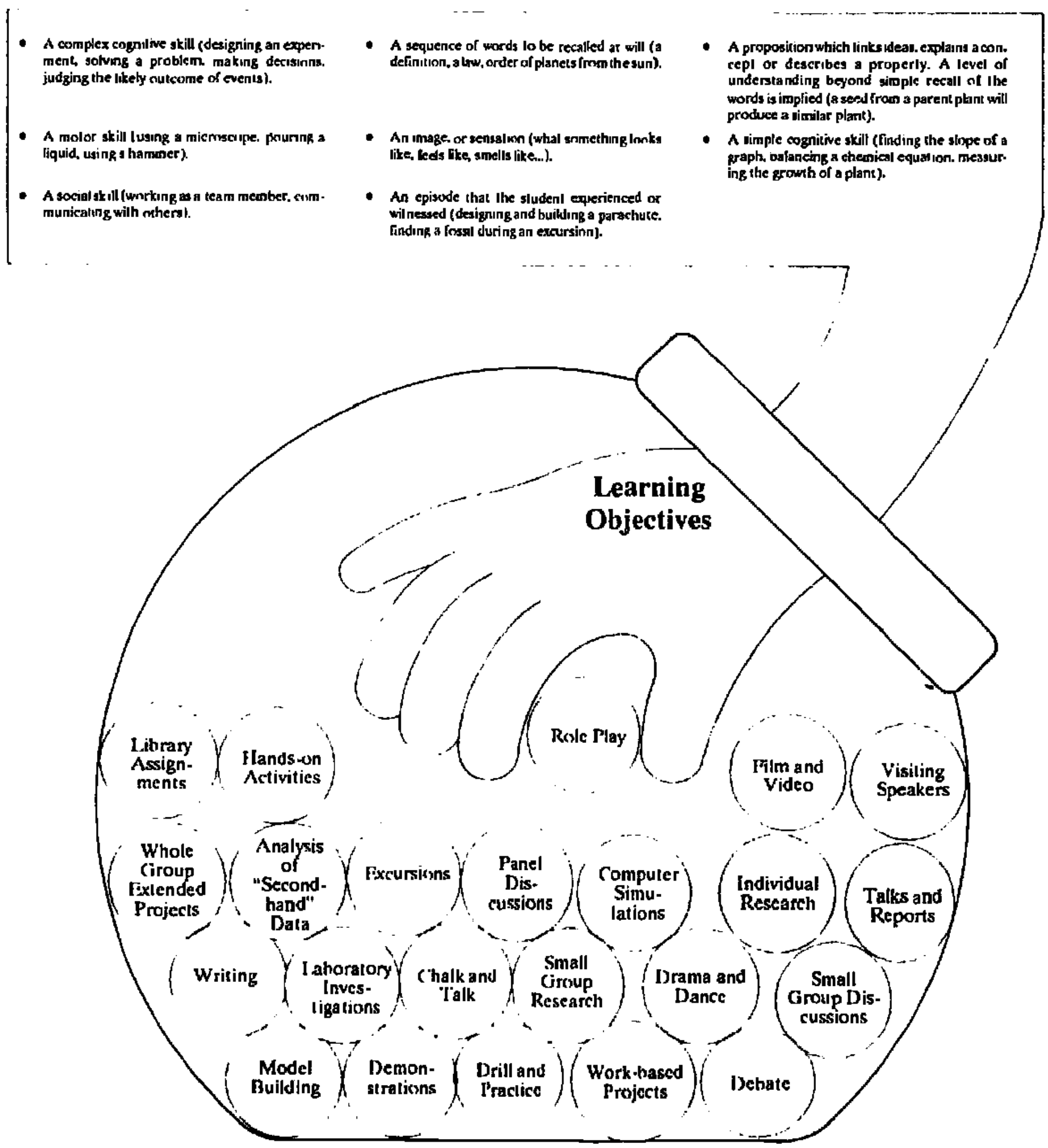
Each entry point makes a different statement about what is "worth knowing". For example, starting a topic "conditions for life" from the theoretical perspective, we might seek generalizations about "living" and "non-living", looking to classifications and interactions. Aspects of technology and society would be picked up along the way. Starting from Technology, we might take a farming perspective: what are the conditions required for life, to maximize yield and ensure the long term health of the ecosystem that is the farm. The farm might be cattle, crops, fish or microorganisms. The theoretical and social aspects would be built in, but the selection of ideas and the emphasis would be different from the first case. Starting from a social issue might follow a theme of hygiene, nutrition, or disease, building science and technology in to illuminate the issues and reach for solutions.

This particular strategy overcomes the traditional debate about "process versus product", by shifting attention to the student and recognizing the importance of context. Process has little point if it is not geared to a product; product derives its purpose from context. The context needs to be one which the children relate to – their immediate environment, a fantasy world, a story, a problem, a hero.

Teaching Approach: Examples

The teaching approach should have two features:

- It should employ a range of teaching methods, to suit the different learning styles of students and the different learning objectives. (See Fig.2)



- It should support "constructivist learning" for all students. Accordingly, the first step should give students opportunities to clarify what they already know, set directions, and contribute their own contexts and experiences. The first segment will often be an open exploratory one: brainstorming, concept mapping, drawing, in response to questions like What do we already know about.., How many ways can we... What might be the variables that determine..What would happen if.... The second segment is to challenge the students' current knowledge – through an experiment, a demonstration, an argument. The third segment is a teaching sequence which carries forward the students' understanding. The fourth is opportunity to apply and extend the new learning.

Following this broad strategy, topics like cosmetics or machines do not in themselves exclude some groups from the learning and include others. The Cosmetics unit starts with the students doing a survey: What cosmetics are in your home? Used by Mum? Dad? Baby? What is a cosmetic? Collect advertisements on cosmetics. What are the advertising strategies?

An alternative to brainstorming is to start with a story or problem. For example, "Separation of Mixtures" can be presented as a technology problem or social issue. The Framework presents this approach in a "case study" called *Green Gunge* (see chapter 3).

Managing Students' Work: Work Requirements

One way of assisting students to manage their own learning and work cooperatively with other students is through projects and "work requirements". A work requirement sets out the work that has to be done by the student, in terms of the product to be produced, the process to be followed, the ways the work will be checked, and the criteria for satisfactory completion. The level of performance on specific criteria can be worked out in discussion between the teacher and the student, to ensure that the expected level is on the one hand achievable and on the other hand challenging for the student. An example of a work requirements for students in Year 8 are given in Fig 3, below.

Fig.3 Work Requirement Year 8, "First Aid"

Unit Plan: Students develop a list of types of accidents requiring first aid. Groups select an accident from the list and develop a presentation to the rest of the class. Groups will: investigate causes of the accident, refer to first aid publications, prepare scripts and rehearse their presentation, develop special effects to simulate the injury or condition, present the information to the class. Each presentation will include a brief description of the body system which is associated with the accident.

At the conclusion of each presentation, each student in the class will construct a concept map that illustrates their understanding of the structure, function and operation of the body system discussed in the presentation.

Work Requirement: The student will present a written report which describes the causes and symptoms of the condition, outline the means of diagnosing the condition, describe past and current methods of treatment and associated technologies, analyze an ethical issue underlying either the diagnosis, selection for treatment, treatment, or rehabilitation of a patient suffering from the condition, and present an argument for the stance that the student would take on the issue.

Fig 4. Science Content

Themes

The following themes are to be incorporated throughout the Programme:

- Environmental education and the Australian environment
- Work education
- Science and our way of life
- Australian science

Local science

Topics drawn from current events, whether local area study, national, or international events, as well as student's interests.

- Quarry study
- Investigation of living and non-living things around the local creek
- Butter factory excursion
- Dairying study
- Rubbish investigation
- Supermaket excursion
- The school environment: Keeping the oval green
- The school environment: People paths
- Consumerism and product testing

Experience

- Using all senses in a wide variety of experiences, with natural phenomena and technologies
- Working together in groups
- Working as individuals
- Finding out in a variety of different ways
- Making things
- Handling animals
- Succeeding
- Enjoying science and science activities

Contexts

Students will use their learning:

- At home: kitchen, garden, workshop
- Farm: machinery, animals, crops, weather
- Current affairs: local, state and national events
- Leisure: sports, entertainments, hobbies
- Work: at home, part-time employment
- At school: furthewr learning

Skills

- Observing: using the senses, measuring, estimating, classifying
- Finding out and experimenting: guessing, creating, making, speculating, using, planning, designing, implementing, interpreting, solving, analysing, evaluating.
- Applying: building, solving, creating, using, making, designing, inventing, planning, organising.
- Communicating: cooperating, examining dilemmas, reporting, recording, explaining, presenting, discussing, writing, reading, listening, debating.

Attitudes and values

- To care for the welfare of people and other living things
- To be open-minded and value objectivity
- To value both natural and manufactured things
- To wish to use science and technology responsibly
- To have a thirst for knowledge and understanding
- To be prepared to work cooperatively

Knowledge

Matter

- Materials around us
- Materials in different forms
- Materials for particular purposes
- Properties, uses and structures
- Manufacture and fabrication
- Planets, stars and galaxies

Energy and Interaction

- Measuring change
- Our energy needs, building and cleaning up, moving and sustaining
- Energy sources and resources
- Energy transfers and transformations
- Change (geological and astronomical)
- Producing new substances

Life

- Growth, and maintenance of individuals and communities
- Ourselves
- Communities and ecosystems and change
- Living and non-living; life and death
- Evolution, life reproduction and death

A Sample Course: (Each unit occupies a quarter of a year)

Year 7	Science Around Me	Caring for Animals	Time and Space	The Environment and me
Year 8	Why Waste?	Electricity for Us	Earthquake in our town	First Aid
Year 9	Have we got the energy	Detection	Everyday Chemistry	Survival
Year 10	Science in the	Moving	The Earth and	Protection

Content

The Science, Technology, Society, Personal Development approach that we are taking was described earlier. The details of content at any particular school are decided at the school level. The *Framework* suggests criteria for selecting content:

- Is it based on the experiences and interests of the students, whether through local or global considerations?
- Does it excite wonder and pleasure in the learning?
- Is it perceived by students and the community as immediately valuable in the world beyond school?
- Does it enable students to develop knowledge and skills relevant to their career and personal aspirations?
- Does it contribute to the programme aims?

The *Framework* suggests content under headings of skills, attitudes and values, concepts, themes, local science, particular experiences, and contexts in which students might be expected to use their learning (see Fig 4.)

Assessment

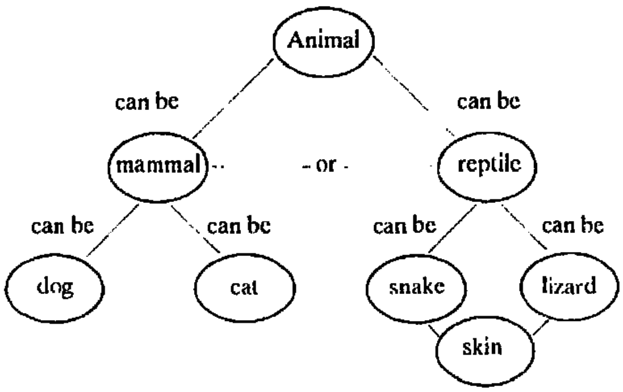
Assessment serves a number of purposes. One is for credentials or grading. This is "summative assessment". Another is to support and guide learning. The focus of assessment at the years 7 and 8 levels is to guide learning. It follows that assessment is an integral part of classroom activity, and must be a responsibility of students as well as teachers.

Students must be encouraged to ask themselves about their current understanding, to consider how the work they are doing links in to work they have done earlier and experience beyond school.

Teachers must be encouraged to use a variety of assessment methods. These will include direct observation, assessment of the range of products that students produce (written work, talks, drawings, models, constructions), interviews, questionnaires and tests.

Assessment for learning does not occur only at the end of the task: if it is to be a part of the curriculum planning it must occur near the beginning and at appropriate points throughout the task. Concept maps and checklists are two devices that can be used.

Fig 5. Assessment through concept maps and checklists



Concept Map Constructed by a Year 1 Pupil from Given Concepts

Attitude — WILLINGNESS TO COOPERATE

Descriptions			
	Unwilling to share Materials or activities with others unless constantly supervised; seems unaware of others' needs and attends only to his or her own interests.	Works together with others and shares materials because of "rules" or incentives to do so rather than by mutual agreement. Depends upon external authority to settle differences.	Responds to the needs which others have to help or materials and tries fit in with others, settling differences without appeal to adult authority.

Stage of Development					
		Feb.	May		

Concept — CONCEPT OF ENERGY

	Considers energy as if it were a substance which is created and lost somewhat magically, without any continuity between one form and another.	Identifies energy in various forms and recognizes its conversion from one form to another, but considers that it can be created at some point in a chain and used up at others.	Describes the changes of form of energy which take place in simple energy chains, recognizing that when it seems to disappear in one form it appears in some other.

Stage of Development					

Process — EXPERIMENTING/INVESTIGATING

Descriptions			
	Is unable to progress from one point to another in a practical investigation or enquiry without help, failing to grasp the overall plan of the enquiry.	Tries things out somewhat unsystematically unless the various steps in a practical enquiry are planned out for him or her, in which case he or she uses materials and collects results satisfactorily.	Has a clear idea of the reason for the various steps in a practical enquiry, and can work through them systematically, making reasonable decisions with only occasional guidance.

Stage of Development					

Sample grid for progressive assessment of practical work

		Point scale					
		5	4	3	2	1	
Motor Skills Examples: Organization	Good						Poor
Manipulation	Good						Poor
Follows instructions	Good						Poor
Ability to perform specific task	Good						Poor
Care	Good						Poor
Handling of living material. Sensitive to physiologocal needs of organisms	Good						Poor
Safety	Good						Poor
Inquiry skills Identify the problem	Identifies problem						No idea
Form hypothesis	Good suggestions						No ideas
Design the experiment	Worksble ideas						No ideas
Identify variables	Identifies variables						No idea
Observations	– Accurate – Relevant						Careless Irrelevant
Data collection	Complete						No record
Display data in meaningful way. eg. tabulated, graph, diagrams	Useful						Useless
Interpretation of data	Evidence set out						Statement unsupported
Evaluation of data	Good/critical						None
Predictions based on data	Good suggestions						No ideas
Communication in written report	– Complete – Evidence clearly set out						No report None
Social skills Work with others	Helps others						Unco-operative
Contribution of discussions	Valuable						None
Responsibility	Good						Poor
Persistence	Good						None
Willingness to learn	Good						None

Teacher Education

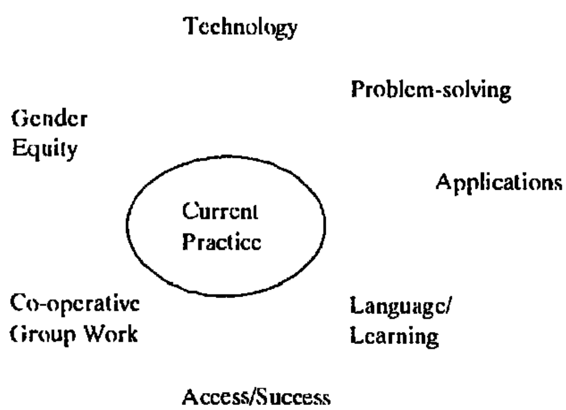
The critical factor in the achievement of access and success for all students is the quality of the teaching .

The quality of the teaching force depends partly on recruitment and pre-service training. It depends also on school factors (management, leadership, organizational support) and the provision of in-service education.

The focus of teacher education, as part of the current changes in Victoria, is in-service education. The number of teachers emerging from college courses each year is only a small fraction of the total workforce, and in any case, new graduates are not in a strong position in the culture and structure of schools to lead school change.

The Victorian reforms require major shifts in educational thought for many teachers. Their beliefs are not changed simply by talking to them about a new policy or handing them a new syllabus and new materials. The required teaching strategy is similar to that listed earlier under the heading Children's Science. Teachers have to be helped to clarify their own educational beliefs and practices, challenged to extend and revise their beliefs, and provided with a teaching programme that supports their learning.

The figure below is from the Framework. It offers self-help for teachers. It says: Consider your current practice. How much do you know about or use the other strategies listed? Reach out and try one, first with a class and in a situation where you are likely to succeed. Talk it over with the Drama teacher or anyone whom you can trust to provide coaching.



Professional development is being provided by the Ministry on a number of fronts:

- The "one shot": *a motivational speaker, a forum on recent research findings, an explanation of new policies: a speech, a workshop, a one day or two day conference. Such "one shots" need to be part of a larger plan, with lead up and follow on activities. Ministry consultants are available to help schools with this planning.*
- Action Research: *Project teams are formed in schools or teacher networks are formed across schools to address particular problems or develop particular innovations. The teams work systematically through cycles of research and action/development, drawing on their "experiments" in class, reading, each other, and outside experts.*
  The Ministry has supported teams working on teaching styles (such as cooperative learning, or students managing their own learning), classroom issues (such as gender bias), course development, and computers in education. The support includes small amounts of money and, more importantly, some release time for teachers and support from outside consultants.
- Sandwich Courses and Contract Learning: *These are offered by some tertiary colleges and other institutions. The Ministry has conducted for some years a successful sandwich course for Mathematics teachers. It is currently developing others for Junior Secondary Science teachers and Technology teachers. In the sandwich course, teachers attend a class in the college/centre, then try out the ideas or gather relevant information in the school, then return for further classes, etc. "Contract learning" is a variation on the sandwich course. The teacher negotiates with college staff a programme based on a project (probably at his/her school) and supporting course work, reading, and tutoring from the college.*
- School projects, conducted with little external support: *When teachers work together to solve a problem, develop a new programme, introduce a new teaching approach, or define a new assessment policy, professional development occurs. Learning in this way is the same as the learning promoted in frameworks through cooperative approaches, projects and work requirements. This sort of professional development is occurring in all schools in Victoria.*

Government policy makes curriculum development the responsibility of groups of people (the school council, the Science Department of the school) rather than individuals. The policy facilitates coordination of programmes in the school. It also promotes professional development through professional interaction with colleagues.

The challenge to provide curriculum access for all in Victoria has been placed largely with teachers. Teachers are giving their energy and their creativity to it. They are becoming sophisticated in their thinking about educational issues and teaching, and more attuned to their own needs for professional development and planning. The face of education is changing.

2. Bhutan

The education system is just three decades old. During these 30 years, education has experienced a tremendous number of revolutionary changes. Now there are 152 Primary schools, 21 junior high schools, ten high schools, one degree college, two primary teachers training centres, one secondary teachers training college, two technical institutions and many religious and vocational institutions.

The medium of instruction in all the schools is English, although it is a second language. Dzongkha is the national language and there are several dialects

The school structure is 7-2-2-3 (seven years primary, two years lower secondary, two years upper secondary and three years at degree levels). Schools throughout the country follow the same curriculum, prescribed by the Department of Education. It is imported from other countries. There are no private schools.

The rich and educated people make good use of the available educational facilities. Underprivileged groups do not. They do not understand the value of education. Moreover, the educational services are inaccessible to people in some locations. There are of course some unavoidable factors which contribute to such problems. Until the problems are solved, ideas of equity, "education for all" and "science for all" are forlorn hopes. The Government of Bhutan is discussing currently a policy of "Universal Primary Education" and its ramifications.

Since the Bhutanese education system is so young and has experienced so many changes, it has not come to a stage of giving special attention to science and technology education, although the importance of it has long been felt.

Bhutan has been importing teachers, curriculum and textbooks, and as a result the children have been learning "Tom Smile lives in London. London is a beautiful city...." instead of learning about their own friends and locality. This is a serious problem. A recent survey reveals that 90% of Bhutanese children knew little about their own country. Consequently, the Government of Bhutan stresses strongly the nationalization of the curriculum to suit their needs and aspirations.

Since 1986, as a result of the 1984 Education Policy, several activities have been initiated: establishment of the Curriculum and Textbook Development Division; introduction of the New Approach to Primary Education for pre-primary to Class III; nationalization of syllabi for Classes IV - VIII; introduction of Druk Series, Biology, History and Geography for Classes VII and VIII. For the current 5 Year Plan, the Government of Bhutan has allocated the maximum budget for the education sector.

Science in Classes I - X is taught as a compulsory subject. Environmental Studies provide the integrating theme for science contents and skills in Classes PP-III. Classes IV - X have separate disciplines. From Classes XI - XV, science studies are optional. The choice normally depends on the marks students obtain in the Class X public examination.

Most of the teachers in lower and higher secondary classes are untrained. Their teaching is usually constrained to the talk and chalk methods of feeding children with ready-made answers for the examination. This includes science teaching.

The whole system is driven by exams and traditional memory tests, in all subjects. There are public examinations for Classes VI, VIII, X, XII and XV. Besides, there are school based examinations conducted by teachers. The examinations hold many pupils back from higher education because they are not able to write the ready-made answers. Examinations are seen more as a means to check the memory power of the children than to find out the achievement problems of the children and try to help them accordingly. Among the subjects offered in the schools, Mathematics and Science are the ones that children are most likely to fail.

Many students complete Class VI, the end of primary education. Only 20% reach Class X level. It is a serious problem. Questions need to be asked, such as: Is there anything wrong with the curriculum? Is the examination system wrong? Is the teacher education system wrong?

Because many teachers lack training in Science, facilities for practical work are often non-existent, schools provide courses for two major groups of students in Classes VII and VIII: those for whom this is their final year at school, and those for whom it is the foundation for further scientific study at higher education levels.

Neither science nor Bhutan will stand still in the next 50 years. All students must be assisted to understand the fundamental and powerful concepts of science and the skills to continue learning throughout their adult and working lives, in order to serve their country to the full. The content needs to be relevant to the needs of Bhutan at present and in the future. It needs to have its roots in sound science. It must enable students to enjoy science, to talk about science, to think scientifically and to start to consider the limitations of science and its interaction with social, economic, technological, ethical and cultural factors.

3. People's Republic of China

Recent Guidelines and Policies

1. The Chinese Government issued "the Compulsory Education Law of the People's Republic of China" in 1986 which will further promote scientific and cultural quality of the whole nation. The Law provides that compulsory education should last nine years and that the school system is the Six-Three System (six years in the primary schools and three years in the junior middle school) and the Five-Four System (five years for the primary school and four years for the junior middle school).
2. As most of the graduates of the junior middle schools in the rural areas will go back to work in the countryside, it is therefore quite necessary to have labour technology lessons and professions technology curricula in the junior middle schools, such as planting crops, raising fish and chickens, training to be carpenters and electricians, building houses, etc., which will really meet the needs of Chinese peasants.

Contents of Science and Technology Education in China's Junior Middle Schools.

Science and technology education includes physics, chemistry, biology and labour technology. A few junior middle schools in China are still having studies and experiments of comprehensive science lessons.

The following are the learning contents and sequences of physics, chemistry, biology and labour technology, with the titles of each chapter and student's experiments only.

Physics (Book 1):

Introduction, simple motion, sound phenomena, heat phenomena, optical refraction, mass and density, force, force and motion, pressure, atmospheric pressure, buoyancy, simple machines, work.

Student's Experiments: Measure length with rulers, measure average speed, measure the temperature of water with a thermometer, study the boiling of water, measure the mass of solids and liquids with a balance, measure the density of solids and liquids with a balance and a measuring tube, study the pressure of liquids, measure the mechanical efficiency of a pulley block.

Physics (Book 2):

Electric current and circuit, voltage, resistance, Ohm's Law, electricity and magnetism, general knowledge of radio communication, mechanical energy, internal energy, heat engines, electric energy, conversion of electric energy and mechanical energy, home circuits, structure of atoms and nuclear energy, development and utilization of energy sources.

Student's Experiments: Connect simple circuit in series and in parallel, measure electric current with ammeters, measure voltage with volt meters, change electric current with sliding rheostats, measure resistance with volt meters and ammeters, make electro- magnet and study its effects, measure the electric power of small bulbs, Install direct current meters.

Chemistry:

Air and oxygen, molecules and atoms, water and hydrogen, chemical equations, carbon and its compounds, iron, solutions, acids, bases and salts

Student's Experiments: Appearance of the chemical change, movement of molecules, purification of crude salt, preparation and properties of oxygen, preparation and properties of hydrogen, preparation and properties of carbon dioxide, prepare solution with percentage concentration, properties of acids, properties of bases and salts, experimental exercises, plus 8 selected experiments.

Biology (Book 1):

Unit 1: Plants: Fundamental structures of the flowering plant, germination of the seed, absorption of water and inorganic salts, production of the substance, consumption of the substance and transpiration of water, transportation of the nutrition, blossom, bearing of fruits and nutritional breed, the whole plant: an integration, the main classification of the plants (Algae, Bryophyte, Pteridophyta, seed plants)

Unit 2: Bacteria, Fungus, Virus

Student's Experiments: Observe the plant cell through the microscope, observe the root hairs and the structure of the root tip, observe the structure of the leaf blade, starch produced in a green leaf under the light, observe the structure of the stem, the operation of nutritious plants, collect specimens of plants, observe yeast and mold.

Unit 3: Animals: Main classification of animals, Invertebrates (Protozoa, Coelenterata, Platyhelminthes, Annelida, Arthropoda), vertebrates (Pisces, Amphibia, Reptilia, Birds, Mammalia), behaviour of animals (main types of animal behaviour, physiological basis of animal behaviour.

Student's Experiments: Observe paramecium through the microscope – the form, the main internal structure, motion, the form of the food vacuole, irritability, fill out the sketch of the form and structure of the paramecium, Observe the form, the reaction to stimulus of the hydra, observe the vertical section (or cross section) of the hydra through the microscope, recognize the ectoderm, endoderm and digestive cavity, etc., observe the form, motion and reaction for the stimulus of the earthworm, dissect the earthworm and observe its main internal structures, organize the students to collect the specimens of the insects after class and to observe their outside characteristics, methods of mounting insects, Observe the form and structures of the marsh shrimp and others, crustacea animals through the magnifying glass, observe the form of the crustacean and observe the action of each fin and observe the phenomena of how water flow into its oral and out of its gills opening, dissect the crustacean and observe its main internal structures and fill out the sketch with what has been observed, observe the form of the frog, dissect the frog and observe its main internal structures, observe the heart beats of the frog, fill out the sketch with what have been observed, dissect the rabbit or other small-size mammals, observe its main internal structures and fill out the sketch

Biology (Book 2):

Unit 4: Physiology and hygiene of human body: brief introduction to the human body, the skin, the skeletal and muscular systems, the circulatory system, the digestive system, the respiration system, the urinary system, the endocrine system, the nervous system, reproduction and development, immunity, infectious diseases.

Student's experiments: Observe the slice of oral epithelial cells of the human body through the microscope, draw a sketch of an oral epithelial cell and indicate the names of each part, observe the slices of four basic tissues through the microscope and contrast the structural characteristics of each one, observe the structures of a long bone, appraise its composition and understand how fragile the calcified bone is, observe blood smear through the microscope and identify the red blood cells and the white blood cells, observe the structures of a mammal's heart, observe the blood flow in the frog's web through the microscope, observe the rhythmic pulsation of the frog's heart, observe the digestion of starch by salivary amylase, observe the small intestines microvilli of the pig (sheep or chicken) by a magnifying glass, verify that the gas exhaled from the lungs contain more carbon dioxide, test the difference of chest girth between inspiration and expiration, test the lung vital capacity in some schools with better laboratory conditions, do the experiment of knee jerk reflex, do the experiment of frog's scratch reflex, do the experiment of formation of image for understanding the eyeball's function, observe the pathogen through the microscope.

Unit 5: Elementary knowledge about: heredity, evolution and ecology, heredity and variation, evolution, living things and their environment.

Labour Technology: Woodwork, technology of washing fabrics, cooking technique, knitting and embroidery, how to plant and look after trees, how to plant flowers, how to plant crops, how to breed the cattle and poultry, repairing bicycles, how to sew, photography, hair cutting, typewriting, how to install electric circuits in the home, how to plant mushrooms, how to cultivate the improved varieties of crops, processing with machines, how to use farm machines, how to process the farm products and by-products.

Characteristics of Science and Technology Education in China's Junior Middle Schools

1. *Fundamental knowledge is paid attention to,* for example: biology as an example, the students may learn the form and structure, physical functions, habits in daily life, classification, inheritance, evolution and ecology of living things, and other systematic and comprehensive knowledge and their application in daily life and production. The students may also learn autopsy and physiology and health, understand the advantages of taking exercise and having good habits of personal hygiene. The contents in every teaching hour are neither too many nor too difficult so that the students will not be burdened.

2. *Experiments are important.* For example: biology observation, illustrations, experiments, visits, practice and experiments after class are carried out during the process of study. While teaching, teachers should raise questions from the above activities and guide the students to think and draw scientific conclusions. By studying biology, the students may develop their observing, experimenting, thinking and self learning abilities.

3. *Science and technology education must take the young age of the lower secondary students into consideration.* It is advisable to use elucidation and interesting methods of teaching. In biology

books, there are a large number of pictures, interesting questions and inspiring outside reading materials.

4. It is appropriate to have some fundamental knowledge of modern science and technology acceptable to students of the lower secondary level. In the biology class, students are told about tissue culture of plants, behaviour of animals, bionics, immunity, balance of ecology and environment protection, etc.

5. *It is essential to combine theory with practice.* Lessons usually start with practical questions in daily life familiar to students. Then students are guided to the subject and they are allowed to apply science and technology to practical life themselves. The following are real examples illustrating science for all:

   Physics: After studying how to use lenses, the students may know how to protect their eyesight; and after studying an electric lighting circuit, they may understand how to use safely electric devices.

   Chemistry: The students come to know the cause and prevention of air pollution after studying air; and they will be able to determine acidity of soil if they study bases, acid and salts.

   Biology : After lessons on seeds, the students may learn to determine germination percentage; they should be conscious of protecting frogs and birds with the knowledge of higher animals; and they will know more about puberty hygiene if they study the growth and reproduction of human beings.

6. *Organize more and better extra curricular activities of science and technology.* In teaching biology, the teachers should ask the students to collect and make samples, plant trees and work together with them. Such activities beautify the campus, arouse the students' interest and train their abilities, and also improve the teaching conditions.

Some Problems and Their Solutions

1. Only some of the junior middle school students will enter the senior middle schools and universities. The majority of them, especially those from the rural areas, do not possess the knowledge and skills needed to take part in productive labour.

   Solutions:

   a) Reform the teaching plan, syllabi and textbooks for the subjects concerned.

   b) Develop secondary vocational and technological education.

2. Lack of teachers and their comparatively low level of education

   Solutions:

   a) Increase participation in teacher training colleges and schools.

   b) Offer regular lectures on professional knowledge and teaching theories and sponsor model lessons based on teaching research.

c) Set up teachers' training colleges at provincial, municipal and county levels and give training courses to teachers who are either released from work or partly released for six months up to three years.

d) Provide better-quality teaching reference books and teachers' handbooks.

e) Encourage teachers in the same community to prepare their lessons collectively.

f) Set up more subject teaching and researching sections and let veteran teachers help inexperienced ones.

g) China has opened a Television Normal College by using satellite TV channels to train teachers in mountainous and remote regions.

4. India

India is quite diverse both geographically and culturally, with a range of languages, professions and religions. The pattern of education particularly, at the school stage, varies from state to state. The studies and recommendations of Education Commissions set up from time to time gradually brought in changes in policies on school education. At present a national pattern of 12 year schooling has emerged as 10 + 2 with first 10 years as general education. It has Primary (5-10 years), Upper Primary (11-14 years), Secondary (14-16 years) and Senior Secondary (16-18 years). Education is compulsory up to the age of 14. The term lower secondary in the context of this workshop refers to the first ten years, that is up to the age of 16.

Science has remained one of the essential components of school education from the beginning with slight variations of bifurcation at 8 or 10 years schooling. Science education has come a long way to occupy a central position and has received repeated emphasis from policy consideration as reflected in 1964 Education Commission Report, the 1968 National Policy and successive 5 year plan documents. The implementation phase the (1875-86) of the 1968 policy brought in a shift in science education at the secondary stage towards making it more interesting, meaningful and relevant to the children and their daily life.

The National Policy on Education (NPE 1986) has again stressed the importance of science education. The policy is the culmination of several regional and national seminars and meetings on national goals and curricular concerns. The exercise involved large numbers of educationists, scientists, planners, administrators, teachers and parents. The review of the earlier efforts helped in the identification of weaknesses, strengths, areas of failures and successes (documented as Challenge of Education). The recommendations in the policy document in general and science in particular derived strength from the above document as well as from the study of the Working Group on Science Education set up by NCERT. This group comprised of people from school and higher education, scientists and researchers.

The policy document highlights the need for *expanding* and *extending* the opportunity of science education to larger populations of school children and through the non-formal system to others of this age group. This strengthens the efforts for providing science to all. Further it emphasized the need for:

- Synthesis of change-oriented technologies and continuity of the country's cultural traditions;
- Inculcation of scientific temper among the younger population;
- Incorporating national concerns such as protection of the environment and observation of small family norms as themes in the school curriculum;
- Removal of social barriers and inculcation of world outlook;
- Fostering broad based human values.

The document, while outlining the scope of science education, has made specific recommendations mentioned below, to make science learning more meaningful, interesting and relevant while extending to all:

Science Education

Science education will be strengthened so as to develop in the child well defined abilities and values such as the spirit of inquiry, creativity, objectivity, the courage to question and aesthetic sensibility.

Science education programmes will be designed to enable the learner to acquire problem-solving and decision-making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. Every effort will be made to extend science education to the vast numbers who have remained outside formal education.

Environment and Education

There is a paramount need to create a consciousness of the environment. It must permeate all ages and all sections of society, beginning with the child. Environmental consciousness should inform teaching in schools and colleges. This aspect will be integrated in the entire educational process'.

Curriculum Development and Implementation

Curriculum development is an important phase of education and it is an essential component for translating the expectations of the national policy. The Department of Education in Science and Mathematics (DESM) of the National Council of Educational Research and Training (NCERT) is the department entrusted with the development and implementation of the curriculum in science and mathematics. It collaborates with other departments and units of NCERT, SCERTs in states, state departments of education, universities, research institutions and schools. It also works in close liaison with international organizations like UNESCO, UNEP and others.

The present phase of curriculum development in science for different levels of school education is the extension and reinforcement of the earlier curriculum of the 1975 phase along with the incorporation of recent national concerns and recommendations of the National Policy. The steps can be summarized as follows:

1. Review of the earlier policy of 1968 to identify strengths and weaknesses.
2. Reframing of the National Policy (1986) keeping in view the earlier feedback and also the present national goals and concerns including the global concerns and expansion of scientific and technological information (NPE 1986 document).
3. Detailing out the nature of the school curriculum, specially the objectives for each stage, courses to be offered and translation of other expectations of policy (National Curriculum for Elementary and Secondary Education - A Framework).
4. Development of guidelines for curriculum developers and implementors particularly for science education.
5. Development of syllabi in science providing details of course content, activities and expected outcomes.

6. Development of an instructional package comprising of textbooks, teacher resource materials, evaluation materials, laboratory materials and supplementary reading materials.
7. Development of enrichment materials for curricular as well as co-curricular activities such as out-of-school science activities (science clubs), science exhibitions, science magazines, newsletters and others.
8. Development of guidelines and training of functionaries responsible for curriculum development and implementation at the state level.
9. Training and development of materials for teacher educators/trainers responsible for teacher training.
10. Development of guidelines for strengthening schools specially in science laboratories and libraries.
11. In-depth study of curricular materials implemented to obtain feedback for continual revision, improvement and for the next cycle of curriculum change.

These efforts are expected to help overcome constraints such as lack of detailed guidelines for curriculum development, implementation, strengthening school resources and lack of trained personnel at state level.

Science Curriculum at Secondary Stage

The essential features of the science education curriculum in the light of NPE (1986) are mentioned briefly below:

1. Science teaching continues to be an *essential component* of general education in the first ten years of schooling.
2. Every child has opportunities to learn science during the first ten years of schooling.
3. Since science would be available to all children irrespective of sect, caste, creed and economic status, attempts have been made to make it more meaningful, and relevant to daily life of children.
4. The science curriculum would provide learning experiences, for developing problem-solving and decision-making abilities, inculcating scientific attitudes.
5. Science up to secondary stage (10 years) has not been presented as disciplines since the child experiences it as a cumulative experience related to life.
6. Efforts in the present science curriculum have been directed to make learning child-centred utilizing daily life experiences so that the child appreciates the role of science knowledge in the improvement of living and also the quality of the environment.
7. Technology education has been built into science rather than being a separate subject.

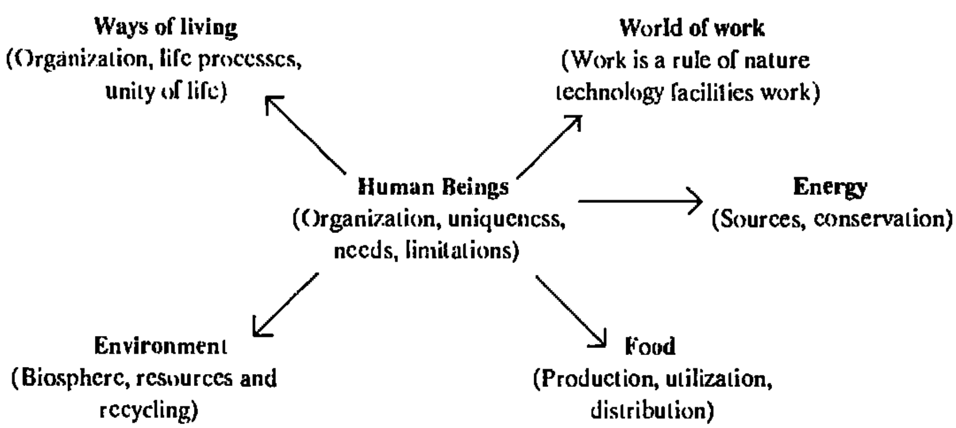
The science curriculum developed recently aims at consolidating the abilities, competencies and skills achieved at particular levels, say, after primary, upper primary at the next level. The science curriculum towards the terminal stage of secondary level expects that learners would be able to:

- understand the nature of scientific knowledge;
- apply appropriately the principles, laws and theories of science while interacting with the environment;
- use processes of science in solving problems, making decisions and furthering the understanding of science;
- interact with the environment in a way consistent with science values like keep aside prejudicial, social barriers for environmental protection;
- understand and appreciate the role and relationship of science and technology with society;
- develop interest in science and related issues and enjoy a richer and exciting view of the world around;
- develop manipulative skills associated with science and technology.

Course Content

The science content of the secondary curriculum is based on earlier knowledge at primary level. In addition, the above objectives have been the basis for determining the content (syllabus), which has been framed in detail, listing concepts, sub-concepts, supportive teaching/learning situations/experiences/activities. The expected outcomes in terms of knowledge, skills, competencies are indicated. The syllabus also provides hints to textbook writers about depth, treatment etc.

The content themes of the syllabus for the age group 11-16 are woven around human beings, their environment, daily life experiences of children and the community. Accordingly the textbook developers have developed instructional packages based on themes such as science in daily life, things and changes around us, important environmental resources like air, water, soil, energy and useful plants and animals. Other basic scientific processes, practices, principles have also been included with examples from and with relevance to daily life.



Outline of basic themes of the Science Curriculum

Efforts have been made to provide knowledge essential to both rural and urban populations on themes like health, nutrition, diseases, energy, industry, agricultural implements and practices.

The course coverage lays overall emphasis on components of environment, natural resources, relationships between humans and environment, inter-dependence and utilitarian aspects of scientific knowledge and technology, and science applied to understanding the biological unity of the human race, irrespective of caste, colour, creed, religion and language. The terminal part of secondary education (Classes IX-X), covers content from a historical perspective of technology vis-a-vis human needs and gives a feel for the role of science and technology in determining the quality of life and the role of citizens in national development.

Some examples:

- Science in daily life, use of scientific methods such as observation, collection of things around, deal with relevance of scientific knowledge.
- Collection of materials and classification on the basis of solids, liquids and gases. Students also learn to tabulate the information.
- Gathering of information from grocer shops, mechanic shops, farmers, fruit and vegetable sellers on diet habits, requirements, sources of pollution make them realise that scientific knowledge is inseparably connected to family, community and society and not a product of contrived situations.
- Recall of information through pictures of daily life experiences/objects about motion (Jhula), fly player, movement of moon give children opportunities to identify and understand application of principles of science.
- Knowledge on acids and bases is related to acidity in the stomach, acidity of soil, environmental effects.
- Using knowledge of motion, children calculate distance, average speed from their activities like travelling on foot, cycle, bus or train.

Activities based on daily life objects and situations covered in all themes encourage children to question, seek answers, be curious to know, interview elders to gather information on plants, animals, food and fodder production.

The discussion in the course on human beings, their uniqueness and evolution helps children understand more about humans, vis-a-vis other organisms of the environment.

The unit on energy exposes children to sources they use, disadvantages of over use, hazards of nuclear energy, reducing pollution and need for conservation at individual and group level would help children to apply the basic knowledge on energy gained through this theme.

The examples of food chain giving scientific aspects of vegetarian diet, relate to food chain, biosphere, disturbance to mineral cycles because of the use of fertilizers. The examples encourage children to appreciate the need for harmony between humans and environment.

The examples on soil structure, fertilizer use, and pesticides, help children to apply the knowledge to growing crops, vegetables and ornamental plants.

Strengthening Teacher Education

Experiences and feedback of curriculum implementation, at the level of teachers, from the beginning and specially during the 1975 phase, helped in strengthening teacher education component. Summer institutes of 2-3 weeks were organized.

It is felt, in spite of all sincere efforts, implementation still was not backed up by intensive training of classroom teachers both in terms of numbers and quality of training.

The curricular reforms after 1986 and review of earlier teacher training efforts necessitated the corresponding strengthening of teacher education both at pre- and in-service levels. The policy document recommended improvement of quality of teacher education and also the working conditions with reinforced school resources in terms of laboratories and school libraries.

Pre-service Teacher Education

As a first step many schemes were launched to deal with teacher training. It was decided to start District Institutes of Educational Training (DIET) at district level. These institutes are responsible for pre-service training of 2 or 3 years for nursery and elementary teachers. They also hold regular training programmes for working teachers on a continual basis.

The National Council for Teacher Education (NCTE) has been framing degree courses for Bachelor and Master level as pre-service training in collaboration with university departments of education. Based on present curricular changes in science education curricular contents for a two year programme with details have been worked out and put into practice in some places.

Reinforcing In-service Teacher Training

In order to reinforce the in-service training programmes specially after 1986, many centrally sponsored schemes were started to orient and train the classroom teachers.

1. *A national scheme of in-service training for school teachers (Programme of Mass Orientation of School Teachers, PMOST)* was planned for training 500,000 teachers each year for the period 1986-90. The short term objective was to create awareness among the teachers about major policy thrusts and curricular changes introduced recently. It was gradually made more of training oriented from awareness, with the strengthening of academic components.

   Ten day Summer Orientation Camps were organized all over the country to initiate, and motivate the teachers so that they appreciate the need for training on a continual basis. The Course Directors/Key Persons were oriented for 3 days in advance to enable them to organize the course successfully. They, in turn, organized 5 day orientations of state level resource persons. More than 10,000 resource persons have been oriented under this programme.

   Training modules relating to following areas were included:

a)	Policy issues and thrusts	4 Modules
b)	Community/School	4 Modules
c)	Pedagogy orientation	9 Modules
d)	Attitudes and value development	8 Modules
e)	Subject oriented material	8 Modules

A telecast in different languages was made during the training camps. Each camp was provided with a TV set.

The programme was monitored through observers and feedback directly obtained from the participants and resource persons. A review for 2-3 days was done with course directors for taking remedial measures for qualitative improvement.

The constraints such as media support, timings and scheduling of camps, board and lodging, were overcome gradually with flexibility at local level.

Constraints include:

- Shortage of suitable speakers;
- Combining of all teachers in one batch overlooking their subject background and level;
- Shortage of relevant media programmes;
- Dilution from key person to teacher through resource team. This was overcome to some extent by introducing more modules.

2. *Scheme for improvement of Science Education in Schools.* For science teachers an additional scheme was launched. Since PMOST was mainly for creating awareness, subject needs of teachers could not be fulfilled. The scheme was started for overall improvement of science laboratories, school libraries and the training of science teachers. The scheme was to help mainly in:

   - improving and strengthening science laboratories;
   - upgrading library facilities by addition of science books and magazines;
   - establishing District Resource Centres in science education for teacher training;
   - training science and mathematics teachers;
   - seeking assistance and involvement of voluntary organizations.

   District Resource Centres are expected to utilize the expertise of DIETs and Colleges of Teacher Education. The resource centres will:

   - organize seminars/workshops;
   - offer advice on a continual basis;
   - help teachers/schools in organizing co-curricular activities for children;
   - publish science education newsletters and magazines.

   The scheme is sponsored and financed by the Central Government. Initially 500 summer institutes of 3 weeks duration are being organized by NCERT and State Education Departments. This will be followed by 2 weeks training programmes by the State Governments. The University Departments of Education from the higher education sector are being involved in the training of subject teachers. The teachers for the upper primary or elementary level will be trained by DIETs.

3. *Environmental Orientation to School Curriculum:* Environmental education is a priority. Hence a centrally sponsored scheme was started to strengthen the science curricula with environmental aspects. The scheme is being coordinated by NCERT. Under the scheme, it is planned to set Environmental Education Cells in State Education Departments..

   The project areas with specific environmental situations and problems will be identified with the help of voluntary organizations. Short term in-service training courses for science teachers will be organized by voluntary groups working in different areas.

Reinforcing Teaching Resources

The new thrusts in the science curriculum and expectations for developing skills, decision-making abilities and attitudes would require adoption of a variety of teaching resources, educational technologies available and programmes being telecast already on science.

With the introduction of new curricular materials, teachers were invited to sit with pedagogy experts and identify the content areas/topics which needed reinforcement by teaching resource. A set of charts related to biological concepts were developed by the Department of Education in Science and Mathematics (DESM), and the Central Institute of Education Technology (CIET), with the help of University experts and school teachers. These have proved quite useful for clarification of concepts both at the level of the teacher and of the child. They can be used either individually or by groups. Another set is under preparation.

Video Cassettes for teacher training have been prepared on *Science is Part of Life*, depicting the needs and means to link science with daily life situations. A video programme on methods of science has been developed.

Co-curricular Activities to Strengthen Teaching

Other areas which are being fruitfully employed for promoting science education include out-of-school activities, science clubs, science exhibitions and science magazines. They provide opportunities for teachers to involve students in investigatory projects to create interest and develop certain skills like use of tools, kits for carrying out projects and models.

Evaluation of Pupil's Achievement

Evaluation of learning is still continuing through traditional examinations which concentrate on cognitive aspects. The examination system has influenced curricular implementation, and proved to be a severe constraint for curricular reforms. It is conducted for grading the students rather than assessing the learning. The real purpose of pupil evaluation for science learning, to assess the extent of achievement of goals and objective observed as change in behaviours, is largely ignored in the present examination system.

The impact is reflected in:

- reluctance on part of teachers to go for innovations, on alternative teaching strategies.
- children's attitude of casualness towards examinations specially among the brighter ones.
- reluctance on the part of examining bodies, and lack of trained personnel to go for more objective assessment.

Many curriculum developers feel that the present examination system discourages a scientific way of learning, understanding and application of knowledge. The introduction of the present science curricula, with its emphasis on affective objectives, requires drastic reforms in examinations at the secondary level.

Item banks are being developed with the help of teachers and subject experts. Items for different types of objectives are prepared for the whole course. They help the teachers. They can also help pupils train for the examination.

Examination reforms recommended by the 1986 Policy are being gradually introduced. A comprehensive evaluation scheme with evaluation instruments for general topics such as attitudes, interest, have been developed for tryout and introduction in boards of examinations. The number of application type of questions are being used increasingly to assess the ability of the children to apply their knowledge of science concepts. The trend for providing more imaginative and application types of questions have also been introduced in the textbooks.

The possibility of making objective based assessment of achievement even at the school level, where teachers have freedom and evaluate their own pupils, is not being utilized. This probably speaks of lack of the training to assess specially the affective domain and secondly a shortage of appropriate instruments of measurement for the affective domain.

The instruments developed, in a comprehensive scheme of evaluation, such as rating scales and checklists have been prepared for measuring attitudes such as towards studies, teachers, school mates and school programmes. For one activity for observing behaviour, the evaluation tool is given below.

Example: Behaviour Tally Chart

Activity: Field trip to study plants and animals

Name of the learner:

S. No.	*Specific behaviour to be observed*	Yes	No
1.	Moves in field without anything specific to do		
2.	Break plants without purpose		
3.	Moves from group to group		
4.	Questions other group members		

Likewise behaviour checklists can be framed to observe behaviour with regard to laboratory and project work. Here the pupil can be involved in debates, discussion, individual or group work, to assess the interest, attitude and other objectives of the affective domain. The work in development of evaluation tools and instruments specially for the affective domain has not been undertaken for the science curriculum introduced in 1986. This aspect really calls for intensive inputs both in research and training of teachers.

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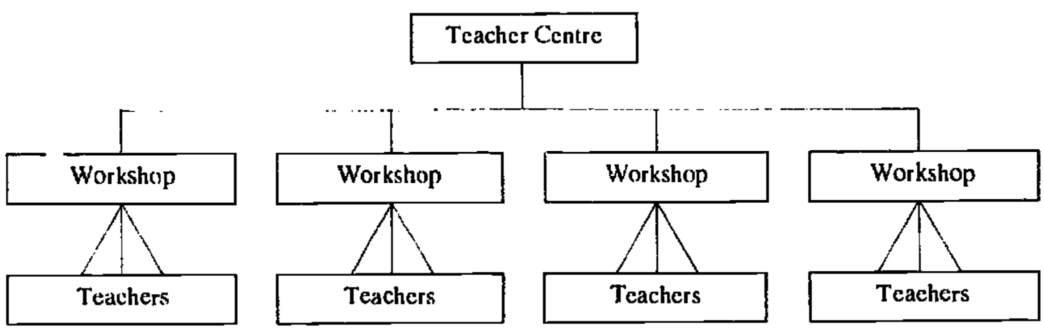
5. Indonesia

Development in Indonesia is reaching a critical phase – the last period of the first national development plan. In the past, the country's emphasis was on agriculture. Now, there is a shift in emphasis to agro-industry. According to the current State Guidelines, educational development will focus on the quality of education. The Government intends a basic education of nine years.

The current curriculum is centralized. The system is 6 + 3 + 3. Up to year 10 every student has the same programme. At year 11 and 12, there are four optional programmes: physical science, biological science, social studies, and culture and art programmes. Since 1984 process skills have been addressed in all subjects and at all ages. Their purpose is to develop students' creativity, scientific attitude, and self sustaining capacity. However, concept-orientation is still dominant.

The teacher is provided with almost everything he/she needs: background materials, worksheets, equipment, and test items. There is a teacher training system which is believed to be effective. It operates through Teacher Centres:



Selected teachers are trained in the Teacher Centre, and then take responsibility to conduct workshops which surrounding teachers attend.

The difficulties that teachers face mostly are lack of resources, too many experiments to be done in class, and an examination system which is concept oriented. Time constraints, consequently, are a major difficulty.

At lower secondary level, even though experiments are carried out and process skills are developed, the teacher is obliged to follow an academic approach. Relating to daily life is difficult. Most experiments are laboratory based, with formal worksheets fixed by central authorities. Creative teachers develop activities which relate science and technology to real life, but mostly as co- and extra-curricular activities.

At the primary level, the situation is better because less concepts are required. The teacher has more time to relate activities to daily life. Concept learning can be linked to improving the quality of life.

The plan to establish nine-year basic education is part of a move towards industrial development. It is an important force in curriculum reform. Efforts are being made at the moment to include the latest issues in education: Science for All ; Education for All, and constructivism theory in curriculum planning.

6. Lao People's Democratic Republic

In Lao PDR, education at all levels, and in all grades, is given in Lao (National Language). The school system is 5 + 3 + 3 (primary, lower and upper secondary). Science and Technology are compulsory subjects at all levels of general education. At secondary levels (both lower and upper) science is taught as separate disciplines.

Policy and strategy on science and technology education at Lower Secondary School with reference to Science for All

The general policies of Lao PDR Government are:

- Education must keep one step ahead and play the key role for opening the way to socio-economic and cultural development.
- Education must be closely linked with productive work.
- Social attention should be paid actively to the development of lower secondary school and should consider it as a central task for being able to accept all pupils who graduate from primary school.

Science and technology education at lower secondary school is intended to:

- enable pupils to have a basic and solid knowledge of science, especially in relation to agriculture, forestry, handicrafts;
- encourage them to use the scientific method in resolving real life problems;
- develop scientific attitudes and mind;
- develop scientific and technological thinking.

The existing curricula for lower secondary schools in Lao PDR has been in use since 1976. The time allocated in the teaching is 8% to biology; 8% to physics, 2% to chemistry; 4% to housework and woodwork, 4% to agricultural technology.

Planning and Implementation Difficulties and Actions Taken to Overcome Them

The Educational Science Research Institute is responsible for the research and elaboration of the curriculum, textbooks, and methods of teaching and learning.

The content of curricula and textbooks is well planned and well organized. It reflects the objectives of Science and Technology Education at Lower Secondary School. Science textbooks are in Lao and reflect the scientific nature of education. However the teaching emphasizes recording and memorizing. Demonstrations and pupils' experiments are not common.

The major difficulties are shortages of textbooks, adequate teaching staff, curriculum materials, equipment and laboratories. According to the new education strategy set up in 1986, programmes to revise curricula and textbooks and to train teachers are underway.

Application of Science and Technology Learning in Real-Life Situations

Science and technology education, as taught in Lao PDR classrooms, has had a tangible and positive impact on the learners and society. More and more now learners and society are aware of personal and social hygiene, and of the use of scientific techniques in production and improvement of the quality of life. However science and technology education has not yet had profound impact on the ways learners and their communities behave.

Learning and Assessment

In the educational strategy of Lao PDR Government , the assessment strategy is stated: Education Boards must be re-structured at each level – student learning activities should be controlled and assessed through the new examination regulations. Assessment addresses knowledge, skills, attitudes and the intelligence of the pupils. Examinations are set and marked by Boards of Examiners at three levels: district provincial and national. The present system of examining students in Lao schools is not satisfactory and preliminary steps are being taken to change it.

The proposed changes deal with assessment under four headings: open democratic and fair assessment procedures; whole-person assessment; core subject assessment; and assessment of what is actually taught.

Teacher Training

Teacher training aims to develop teachers who possess the following qualities:

- a socialist citizen with qualities of the new working man or woman; correct thinking; and abilities for organizing, administering and teaching.
- ability for developing the role of the school in the context of socio-economic and cultural development of the local community.

To be a teacher in the lower secondary school a candidate must complete the lower secondary school level and then undertake three-years training. It is proposed in the educational strategy to change to completion of upper secondary school plus three years training.

7. Malaysia

Current Science Curriculum

At lower secondary level, Malaysia adopted the Scottish Integrated Science Curriculum Grade 7 to Grade 9. At the upper secondary level, the British Nuffield Science Curriculum was adopted, from which two Malaysian programmes were derived: a pure science programme comprising physics, chemistry and biology, and a general science course. The pure science programmes were intended for pupils who are inclined to pursue science. The Malaysian General Science syllabus was meant for those in the non-science stream.

Malaysia has developed an *Integrated Secondary School Curriculum*, locally known as KBSM. It is replacing the above programmes. The KBSM is a curriculum reform aimed to nurture and develop the potential of the individual in the intellectual, spiritual, emotional and physical domains, in a comprehensive and holistic manner. It is based on the National Philosophy of Education:

"Education in Malaysia is an on-going effort dedicated to developing the potential of individuals holistically in an integrated manner so that their development, based on the belief in God, is intellectually, spiritually, emotionally and physically balanced and harmonious. Such an effort is designed to produce Malaysian citizens who are knowledgeable, possessing high moral standards and are responsible and capable of achieving a high level of personal well-being as well as being able to contribute to the harmony and betterment of the society and the nation at large."

The KBSM science curriculum aims to provide learners with opportunities to acquiring scientific knowledge, scientific skills and universal values. The principles which guide the formulation of content in the new science KBSM are:

- Science for understanding of nature
- Science for human well-being
- Science for personal development

The content is organized under four themes:

- Humans and the variety of living things around us.
  A variety of living things; the world through our senses; coordination in our bodies; reproduction and growth; variations and heredity; microorganisms and their impact on humanity

- The wealth of the earth and its management.
  A variety of resources on earth; the air around us; water and solutions; Earth and its resources; matter and substance; carbon compounds

- Energy for living.
  Forms and sources of energy; food and the release of energy; nutrition and food production; heat and its transfer; electricity and magnetism; light, colour and vision; energy and chemical changes; force and motion; transportation and communication

- Humans and balance in nature.
  Interdependence between living things and their environment; balance in nature; Earth and the universe

In-service Training For Science Teachers

The main purpose of the training programme is to orient teachers to the aims and aspirations of the KBSM and the National Philosophy of Education, and to consider the roles of teachers in the implementation of the KBSM reform.

Centralized teacher training programmes and In-House programmes are conducted. The In-House training package consists of printed documents and video-tapes. The documents and tapes provide the information necessary for those involved with planning and implementing the in-house programme throughout the country.

8. Maldives

Since the 1960s, General Science has been taught in the Middle School (ages 12 - 14 years). Until the National Curriculum was formulated in 1984, schools used science textbooks produced in various neighbouring countries. Teachers usually followed the chapters as presented in the textbook. Frequently these textbooks were not bought on recommendation but acquired as aid from another country.

The National Curriculum for Grades 1 - 7 includes General Science in Grades 6 and 7 and in the early years incorporates science concepts in the Environmental Studies Programme. A team of two Maldivians drew up the original outline, based on the West Indian Science Curriculum. The syllabuses had to be supplemented with textbooks. However, due to certain constraints, such as limited expertise to prepare textbooks *Integrated Science for Caribbean Schools I and II* has been used to support the General Science Course in Grades 6 and 7, since 1985.

In the course of implementing the General Science syllabus, constraints were identified which led to a major review of the programme. A two week workshop was held at the Education Development Centre in 1988. Maximum effort was made to draw to the workshop expertise from within the country and outside.

One of the major recommendations of the workshop was that the aims and objectives of science teaching should be clearly spelt out so that the teachers would be guided by objectives and not merely follow the text books. Accordingly, the participants of the workshop formulated aims and objectives for the middle school. In doing so, the following were kept in view:

- the National Educational Goals:
  - To make education more relevant to the local environment.
  - To train the workforce necessary for national development.
- local needs and environment;
- skills and attitudes required in a rapidly changing world;
- traditional culture and values;
- maturity and age level of the students in Grades 6 and 7;
- the middle school as a terminal stage as well as a preparatory stage for higher education.

Aims of Science Teaching at Middle School Level:

1. develop and foster an appreciation of the application of science for human welfare and to instil in them the importance and need for judicious use of the knowledge of science;
2. promote self-learning of knowledge around them through the processes of science;
3. to foster team spirit and a sense of cooperation in acquiring and sharing the fruits of knowledge;
4. help develop independent and constructive thinking;
5. develop the ability to tackle the problems of daily life situations and to find solutions through the application of scientific knowledge and processes;
6. instil and develop in them a sense of responsibility to apply the scientific knowledge and skills acquired towards improving the quality of life;
7. develop in them scientific attitudes and skills to produce scientific and technological manpower for national development;
8. develop interest and curiosity for knowledge and understanding through scientific processes;
9. develop respect for logic and opinion of others, and concern about consequences;
10. help to acquire practical and work-oriented knowledge and skills through learning sc'ence.

Planning and Implementation Difficulties

Among the problems and difficulties faced by the Education Development Centre in its first attempt to implement the Lower Secondary Science Curriculum were the following:

- Shortage of manpower for planning and producing teaching/learning materials. (This problem has been overcome temporarily through involving people from other sectors such as health, fisheries and agriculture.)
- Lack of a science component in the teachers' training programme.
- Science Education is officially to be conducted in the English language. Available untrained teachers are not able to carry out activity-oriented teaching/learning activities in English. (It has been approved now to conduct Science Education at lower secondary level in Dhivehi, when the English medium is not possible. The new textbooks will be translated.)
- Translating Science textbooks from English into Dhivehi poses a new problem of coining new terms – this in turn leads to shortage of books as the process of forming new words is taking a long time.
- Lack of science teaching aids and supplementary materials.
(A basic kit is provided by the Ministry of Education, but it is not adequate).
- Need for producing improvised aids from local materials
- Hesitancy of teachers to adopt activity oriented approaches limits students' attainment .

9. Nepal

Educational Structure

The present educational structure in Nepal is 5-5: five years of primary and five years of secondary. Prior to this, the system consisted of five years of primary, two years of lower secondary and three years of (upper) secondary. A plus 2 stage (higher secondary) will be added gradually to the existing system. His Majesty's Government has already announced that secondary education will be from Grade 6 to 10. Grades 6 and 7 from the previous structure are attached currently either to primary schools or secondary schools.

Changing Face of Science Education

Until 1971, science was taught as an optional subject in high schools (Grade 6 - 10). At that time there were no standard textbooks. There were no clear objectives for school science.

With the New Education System Plan (NESP) in 1971 there was a dramatic change in science education. One of the significant features of NESP was the establishment of the Curriculum Development Centre, now called the Curriculum Textbook and Supervision Development Centre (CTSDC). This centre is responsible for developing, implementing and evaluating the science curriculum.

Currently, a centrally – directed model of curriculum development is in operation. National goals were translated into curriculum objectives and programmes. Curriculum guides were prepared in various subjects including science. Activity oriented textbooks were developed. Orientation and on the spot training programmes for teachers were organized. Science equipment was distributed.

The objectives of the new science curriculum are basically the acquisition of knowledge, skills and attitudes of direct use to the students in their daily lives and understanding.

Organization of the Curriculum

The major curricular goals are set at the national level by the Ministry of Education. They are translated into various subject learning objectives by the respective specialists. The current primary science curriculum stresses the teaching of biology and environmental science. At the lower secondary level the emphasis is on physical and biological sciences, while at the secondary level, science is taught as physics, chemistry, biology, geology and astronomy.

The subject specialists in the CTSDC are responsible for developing and evaluating the curricula. The committee system is used to develop curricula. There are three types of committees. The subject committee is composed of members from different educational institutions e.g. the Institute of Education, university campuses, Educational Directorates and School teachers. The chairperson is appointed by the centre. The subject specialist of CTSDC acts as a secretary to this committee.

The subject specialists first prepare a draft curriculum which is discussed in the subject committee. Improvements are made and the revised draft curriculum is forwarded to the next committee known as the Curriculum, Textbook Development and Innovation Committee organized under the chairmanship of the Chief of CTSDC. After approval by this committee, the draft curriculum is sent to a third committee called the Curriculum and Textbooks Coordination Committee headed by the Honourable Minister of Education and Culture. Only after the approval of this committee is the draft curriculum ready for implementation.

Instructional Time

The total instructional time devoted to science education at primary level is 10% and at secondary level is 13%. That means four periods (45 minutes per period) a week in Grade four to five and five periods a week in Grade six to ten.

Evaluation

An examination unit was established with the introduction of NESP. The new scheme is an integral part of the education system. It has produced standardized achievement tests with limited success. There is a lack of suitably trained man power for the purpose. The new scheme for student assessment includes provision for internal assessment. The next step of the new evaluation scheme is to keep records of the *progress* achieved by individual students.

Teacher Training

After the implementation of NESP, the Institute of Education (IOE), now Faculty of Education, organizes different courses at certificate, diploma and degree level, to produce trained teachers. There are pre-service as well as in service training programmes.

The production of science teachers from the Institute is limited. Lack of qualified and trained science teachers is one of the greatest draw backs, both for schools and for training programmes.

The qualifications required for teaching science at the primary level is the School Leaving Certificate (SLC) and some additional training. At the lower secondary level, one year of science and one year of education with a major in science is required, and in the secondary level, B.Sc. or B.Ed. with a major in science.

The problem with science teachers with M.Sc. or B.Sc. background is that they prefer to take employment outside the teaching profession. They use the teaching job just as a platform for employment elsewhere.

Curriculum Revision

Curriculum development is a continuous process and it has to be adjusted constantly to changing national needs, aspirations and values. In this context, the curriculum has been revised in 1981 and science made optional in grades nine and ten . The main reasons for making science optional are:

- the low achievement of the students
- lack of qualified and trained teachers
- lack of classroom facilities
- high students/teachers ratio
- the teachers are not acquainted with sophisticated equipment.

With the revision of the curriculum, all the textbooks from Grade IV to X are being rewritten so that they suit under-qualified science teachers. Especially in primary and lower secondary grades few experiments were done. So the revised curriculum shifts the emphasis from the student centred textbooks to teachers centred ones.

To overcome the lack of qualified and trained science teachers and to equip the schools with necessary equipment the Ministry of Education and Culture launched a five year programme with the establishment of the Science Education Development Centre (SEDEC) in 1984. This is one of the landmarks in science education in Nepal.

Problems

Most schools, especially primary schools and those in the rural areas, are short of standard classrooms and space. Laboratories, workshops and libraries are almost nonexistent. Nearly all secondary schools have permanent buildings but the classrooms are crowded. Very few well established secondary school have laboratories for science and collections of books for students and staff.

It is widely felt that the quality of education suffered in the course of the recent significant expansion of schools and enrolments. The deficiency in quality is related to physical facilities, instructional materials, trained teacher supply, and no capacity to translate the national goal and curriculum objectives into textbooks, teacher training and evaluation programmes. Because of these deficiencies teaching-learning and evaluation programmes emphasize objectives in the lower levels of the cognitive domain.

Very little research work has been done in science education in Nepal. In the curriculum development process also there is a great difficulty in developing a balanced curriculum for the whole country because of the great diversity in its people and geographical features. There is also very low participation of teachers from some parts of the country.

Primary education has now been accepted at the national level as one of the basic needs of the people.

Recently CTSDC has proposed that science education be made compulsory from Grade one to ten.

The Curriculum, Textbook and Supervision Development Centre has already prepared a proposal to establish an institute to promote school science and mathematics education. It is being on process for approval by His Majesty's Government.

Conclusion

An urgent need to promote science and technology education and relate it to real-life situations in Nepal is strongly felt. The National Science and Technology Policy of Nepal, approved in May 1989, recognizes that the capability of a nation lies largely in its scientific and technological capability. A National seminar on Science and Mathematics Education Policy and Planning held February 1990 was very timely. So is this Workshop.

10. Pakistan

Science and technology have important roles in the current and future well being of humanity. To get rid of misery, poverty, hunger, diseases, illiteracy, social injustice, energy crisis and environmental pollution at national and international levels, introduction of science and technology in the curriculum at lower secondary and higher secondary levels is essential.

The policies of the Government include *Education for All*, and special emphasis has been given to science and technology. Science education is compulsory at lower secondary level (Classes VI to VIII).

Curriculum Development and Implementation

Pakistan has a unique system of curriculum development and implementation. There is a Federal Curriculum Bureau known as the National Bureau of Curriculum and Textbook Development. Under the control of this organization, provincial curriculum development centres develop the initial drafts of the curricula, keeping in view the national and local needs of the students and society. These drafts are submitted to the National Bureau of Curriculum, which finalises and approves them if they are found to be satisfactory. The drafts are then handed over to Textbook Boards situated in each province. Textbooks are developed by the Textbook Boards, and finally approved by the Ministry of Education and the Curriculum Wing. They are printed by the Textbook Boards.

Approach in the New Curriculum

The selection of the subject matter has been made on the basis of:

- the child's intellectual, emotional and physical needs;
- the sciences, especially Biology, Physics, Chemistry and Astronomy;
- the environment, both natural and man made, in which the child lives;
- the objectives we wish to attain; and
- the total school curriculum.

Aims and objectives of science teaching:

- to achieve a broad and genuine appreciation and understanding of different aspects of science and technology;
- to promote scientific literacy and provide scientific and technological manpower for the country's needs;
- to prepare the young generation to solve their own problems, as well as the problems of humanity, at community and global levels;
- to improve the socio-economic conditions of the country.

Planning and Implementation Difficulties and Actions Taken to Overcome Them

Science and technology education is given a special place in our seventh Five Year Plan, and foreign aided projects are also functioning to spread science and technology education at lower secondary and higher secondary levels.

The problems faced are shortage of appropriate funds; shortage of highly qualified people to teach at lower secondary level (due to limited financial resources), and population explosion.

Pakistan is assisted financially by organizations like, UNESCO, UNICEF, World Bank, Asian Development Bank and ODA. The problem of getting highly qualified people to teach science at lower secondary level will take time to resolve.

Evaluation of Pupils Achievement

In teacher training programmes, attention is given to evaluation of pupil achievement, including scholastic attainment and attainment in the affective domain. Measurement and Evaluation are taught as subjects in the teacher training colleges.

Examining boards at the provincial and federal levels use written tests for measuring scholastic attainment.

Teacher Education

Elementary teachers complete one year's training after matriculation to obtain the Certificate of Primary Teaching. Teachers for lower secondary classes (VI - VIII) complete one year's training after BA or BSc, to obtain a Certificate of Teaching.

11. Philippines

Science education in the Philippines has been revitalized. This was the result of major educational reforms instituted in response to the government's thrust of raising national productivity and economic stability, and the educational thrusts of equity, quality, efficiency and relevance.

Two important developmental programmes for elementary and secondary education were adopted. These were the Programme for Decentralized Educational Development (PRODED) and the Secondary Education Development Program (SEDP). PRODED was tasked to improve the quality of elementary education while SEDP will upgrade the quality of secondary education. These programmes were designed to:

1. reduce regional disparities in educational resource;
2. improve pupil performance; and
3. improve overall quality and efficiently of elementary and secondary education.

The programmes operated in phases which were in line with the new developmental strategies spelled out in the 1982-1989 Medium Term Philippine Development Plan. The implementation of PRODED took precedence since priority was given to the improvement of pupils' performance at the elementary level. Its inputs were a new curriculum emphasizing the 3 R's and Values Education; upgraded instructional materials; retrained teachers, administrators and supervisors; and new and repaired school facilities and equipment.

The implementation of the SEDP coincided with the entry of PRODED educated pupils to the secondary level. SEDP continued the improvement started by PRODED along with the pilot testing of the curriculum and the training of teachers.

The expected outcomes of SEDP are:

- increase participation rate (PR) or the number of students per school from 51.5% to 71.5%
- increase internal efficiently (survival rate) of students entering first year and leaving fourth year by reducing drop-out rate in the public schools from 5.8% to 2%.
- increase achievement scores from 53% to 70%.
- develop a new curriculum and new policies for secondary education.
- build 673 school buildings with equipment packages for science, mathematics and work education.
- improve textbook/students ratio from 1.7% to 1.1%.
- improve teacher/students ratio from 1.53 to 1.40.

- train 140,000 public school teachers, 400,000 private school teachers.
- cricnt 5,000 school administrators (public and private).

The general plan for revitalizing the secondary education programme involves the implementation of intervening activities on:

- curriculum development;
- staff development;
- provision of instructional materials;
- research and special studies;
- revision of procedures and systems for greater efficiency in the administration and management of the secondary education programme. Preparatory development activities for the implementation of the comprehensive development programme commenced in 1985. In 1989, the new secondary school curriculum was launched and started with the first year curriculum.

Strategies for Implementing the SEDP Goals.

To improve the quality of education, SEDP focuses on:

- curriculum reform;
- provision of quality textbooks/teacher's manuals on a 1:1 basis;
- provision of science and work education equipment;
- staff development (short and long term);
- assistance to private secondary education;
- research studies on National College Entrance Examinations (NCEE), Barangay high schools, career guidance, etc.;

To effect efficiency in the system, the SEDP focuses on:

- research studies on school location and distribution, financing schemes, teacher's salaries and benefits, etc.;
- strengthening of sector management and evaluation system.

To expand access to the sector, the SEDP plans to undertake/expand:

- the school building programme;
- the service contracting scheme;
- alternative delivery systems.

To ensure equity in the system, the SEDP plans to undertake/expand:

- the school building program for local high schools;
- the equipment provision and technical assistance for disadvantage areas.

Policies and Strategies

A. Overall Policies

Major curriculum reforms were carried out in the context of the Medium Term Philippine Development Plan, 1987-1992. The policies and strategies to implement these policies are as follows:

Policy: Improvement of the quality and relevance of education and training with respect to Philippine conditions and needs.

Strategies:

1. A general curricular and program re-orientation which foster knowledge, skills and values.
2. Revision and development of textbooks and learning aids that will reflect Philippine conditions and experiences.
3. In-service training programs for teachers, administrators and supervisors.
4. Expansion, improvement and maintenance of learning resources, such as libraries, museums and educational media centres.
5. Development of a more efficient system of selection and retention.
6. Increase institutional autonomy to enable schools to strengthen curricular offerings.
7. Create partnership with industry and the rest of society to ensure productivity and enhance relevance of institution.

Policy: Equitable access to education and training opportunities.

Strategies:

1. Development of a socialized tuition fee scheme which is based on the social cost of education and student's ability to pay.
2. Priority in the distribution of teachers' instructional materials, school facilities and equipment to disadvantaged communities and disabled individuals.
3. Provision of alternative training opportunities for the under privileged and disadvantaged sectors of society.
4. Strengthening of the rural based training system.

Policy: Intensification of values education.

Strategies:

1. Identification of traditional desirable Filipino values particularly among workers and potential workers.
2. Integration of values education in the school curriculum using appropriate teaching strategies and character building activities.

Policy: Promotion of entrepreneurial education and training.

Strategies:

1. Emphasis on entrepreneurial training programmes with an agricultural and rural orientation.
2. Installation of vital support systems.
3. Functional linkages with training institutions and industries and non governmental organizations.

Policy: Increased emphasis on science and technology, indigenous research and experimentation.

Strategies:

1. Institutionalization of the teaching of science and technology in both curricular and co-curricular programmes to promote scientific literacy.
2. Emphasis on pre-service and in-service training of science teachers.

Policy: Full mobilization and utilization of education personnel with an increasingly commensurate system of compensation and incentives.

Strategies:

1. Development of programmes for recruitment, utilization, professional development and welfare of teachers.
2. Provision of appropriate incentives for above average students who have the aptitude for teaching.
3. Creation of a differentiated system of career progression for public and private school teachers and staff.

B. Sectoral Policies

Policies at the sectoral level are concerned with the upgrading of the formal school system, particularly in elementary and secondary education. These policies will continue to emphasize the overall policies of:

- a systematic scheme of student intake retention and progression;
- equity in the allocation of resources based on regional needs;
- a more effective utilization and development of teachers and staff;
- stronger coordination of public and private schools;
- improvement of management capabilities at all levels.

C. Basic Education

Policy: Basic science education and science promotion.

Strategies:

1. As foundation for technological advancement, basic education in the sciences will be oriented towards production.
2. Priority in innovations in integrating productive work and in-school science courses.
3. Basic science courses shall serve as an instrument to equip the citizens with skills to develop appropriate technological solutions to specific problems and transform natural resources for productive use endangering the environment.
4. Increase by 30% the number of science and mathematics teachers to be upgraded in teaching competencies.
5. Intensify non-formal education in science through the active promotion and dissemination of science and technology information by the 12 regional science and technology centres.
6. Emphasis on livelihood/employment related technologies.

With these policies a more integrative and in depth evaluation of the formal school system will be done to identify the major problems and issues that affect the sector and to recommend appropriate measures to improve further the delivery system. Public and private schools shall be rationalized to prevent poorly-equipped, understaffed and inadequately financed institutions which turn out poorly-prepared graduates for employment. The revised bilingual education policy will be implemented. The policy states that the medium of instruction shall be in English and Filipino. In addition, the regional language may be used as an auxiliary medium of instruction. Salaries of locally funded high school teachers are nationalized with the implementation of free public secondary education for the school year 1988-1989. Moreover, the operating expenses and capital outlays of the schools shall be nationalized. With regards to limited funds, new sources of financing shall be tapped. A nationwide adoption of the educational contracting scheme to make education accessible to all. This scheme allows students not accommodated in public schools to enrol in private schools at government expense.

Upgrading of science education will be done in two aspects:

(a) the updating and the training of teachers in upgraded methods; and

(b) the provision of science apparatus and facilities. The teacher-training component of the new programme will be undertaken by national centres of excellence (CENTREX), selected private institutions of higher learning. Regional Educational Learning Centres (RELCs). Regional Science Teaching Centres (RSTCs) and selected national or accredited high schools. For the equipment component, the Science Equipment Project will oversee the developing, designing and production of instructional science equipment in some selected secondary schools. The project will also conduct a continuous evaluation of science equipment and training for the repair, maintenance and operation of equipment.

Science Education Development Plan (SEDP)

Before the implementation of SEDP in 1989, preparatory activities for a new Development Plan were undertaken. One of these activities is the formulation of the Science Education Development Plan (SEDP).

SEDP is a joint project of the Ministry of Education, Culture and Sports and the Department of Science and Technology (DOST). It was a research-based study and was conceived on the basis of the growing importance of science and technology within the Philippine Development Plan and was designed to upgrade science education systematically at all levels by providing guidelines and priorities for policies, programmes and projects relative to science education. It took two years and hundreds of people from various sectors and parts of the country through a series of sectoral consultative conferences, survey studies, documentary analysis of pertinent documents, analysis of related literature in science and mathematics education and commissioned studies and paper. The wide participatory mechanism stimulated active deliberation on the directions that science education should take for US Filipinos. By its publication (in 2 volumes), SEDP became a documented basis for describing science and mathematics education in the country.

The policies set down by SEDP were closely linked with the country's development thrust of self-reliance and accelerated productivity. These policies were listed in eight categories in the SEDP's plan of action. These are

- Organization
- Finance
- Curriculum
- Staff Development
- Textbooks and Instructional Materials
- Equipment and Facilities
- Research
- Linkages.

Science and Technology Plan (STP)

Efforts to build a strong science and mathematics education was accelerated by the creation of the Presidential Task Force on Science and Technology (PTFST). It is a multi-sectoral task force composed of representatives from the government, industry and academia. Its mission is to formulate a Science and Technology Plan that will spur the Philippines to become a newly industrialized country by the year 2000. The Science and Technology Plan is a comprehensive sectoral action plan for manpower development in science and mathematics. It hopes to attract the youth towards careers in science. PTFST, in turn recommended the formation of the Science and Technology Coordinating Council (STCC) to assist PTFST and coordinate in the implementation of S & T Plan. STCC is assisted by two panels, namely, the panel for Higher Level Manpower Development and for Science and Mathematics Education. The sectoral panel on Science and Mathematics Education is now working on the details of setting up a network of high schools. The strategy it hopes to follow in order to achieve its objective is to:

- identify the lead implementation agencies; and
- study teaching-training institution's programmes like the Institute for Science and Mathematics Education Development (ISMED) and Philippine Normal College (PNC) from which future teachers will come by minimizing education course requirements, which would make a teaching career attractive to science majors. Secondary schools which play a key role in developing scientists will also be studied. Activities which identify science talents, such as science quizzes, fairs, etc. will be studied. From the results of the assessment, these institutions will be linked into a strong network, its manpower, science materials and laboratories and other resources will be developed.

Selection of schools which will form the network was done on the basis of their needs, such as teacher training, science equipment and stronger science environment for students and teacher. Moreover, these schools are mainly located around a tertiary institution which will serve as a node of the network. Some lead persons and institutions were identified and they will assist STCC in the implementation of the Science and Technology Plan.

The process of implementation for school year 1987-1988 reported major policy and sectoral developments supportive of the policies and thrusts in education and training. Certain key indicators were identified. The overall enrolment performance at 97.16 percent fell short of the Plan target. This shortfall maybe attributed by peace and order and poverty-related problems, particularly in the rural areas. Achievement in elementary and secondary levels was higher than the Plan targets. Literacy rates had increased. However, Senator Edgardo Angara, Chairman of the Senate Committee on Education, expressed in an interview that the scientific literacy of a seventeen year old Filipino is only equivalent to the scientific literacy of a 10 year old Singaporean boy. Teacher-pupil ratio of 1.33 in 1987 exceeded the 1.32 ratio of 1986. Textbook-pupil ratio of 1.2 was maintained.

Major reforms were instituted to achieve quantitative expansion and qualitative improvement in the educational system. Salaries of teachers of locally funded high schools were nationalized. This is in preparation for the implementation of the no tuition policy in public secondary schools starting in School Year 1988-1989 which had been signed into law (Free Secondary Education Act). Scholarships and loan grants to 16,061 qualified students were increased. The Science Scholarship Fund which provides additional scholarship assistance to poor but deserving students who have the aptitude for science was being discussed. Science and Mathematics teachers were trained by the Regional Science Teaching Centres (RSTCs) which provided in-service and diploma programmes to these teachers.

DECS, on its part, issued an order for a moratorium on the establishment of barangay high schools, to arrest the proliferation of substandard barangay high schools. About 30,285 out-of-school youths went back into the school system through the Philippine Equivalency Placement Test (PEPT). Educational opportunities were extended to cultural minorities by accrediting 15 Muslim Madrasah schools in Region I, employing para-teachers in Cotabato, and setting up of tent schools and walking blackboards in the remote areas of Regions I, IX and XII. Mixed classes were set up in areas where the schools' student population did not meet the grade-to-grade class size requirement. The educational service contracting scheme was adopted in Regions VIII & XII. This scheme is an alternative delivery system which is innovative and cost-effective. It allows private schools to take in students who cannot be accommodated in the public schools. The construction of additional classrooms was minimized and maintained the financial viability of private schools. A wider access to education increased enrolment to 14.4 million.

Training programmes were geared in developing the expertise of qualified teachers and enhance the use of technology for countryside development. These covered secondary science equipment improvisation, refresher courses in secondary Physics and Chemistry, intensive courses in Mathematics, Chemistry, Biology and a technician course for science equipment. Eight satellite schools were added to the 13 RSTCs to widen the coverage of the teacher training programmes in the sciences, particularly in the depressed and far flung areas.

Implications for Curriculum Development

"Education is a public function, it is a need as well as a right." This was the strong view articulated by the Fund for Assistance in Private Education (FAPE) President Abraham Felipe during a round table discussion of the Asian Pacific Educational Programme for All. This program seeks to bring education to all by the year 2000. Yet, Felipe noted that the traditional system is bent in developing people for the labour market which encourages emigration at the expense of the students' rural communities. In this aspect, schools must produce citizens equipped for effective participatory citizenship and committed to the needs of the country. Thus reforms in the secondary school curriculum is needed. In 1989 the Secondary Education Curriculum was developed through multi-sectoral consultations and conferences. The objectives of the new curriculum are to :

- develop an enlightened commitment to the national ideals by cherishing, preserving and developing moral, spiritual, and socio-cultural values as well as other desirable aspects of the Filipino heritage;
- obtain knowledge and form desirable attitudes for understanding the nature and purpose of man, and therefore, of one' self, one's own people, and other races, places and times, thereby, promoting a keen sense of self, of family and of national and international communities;
- develop skills in higher intellectual operations and more complex comprehension and expression activities, and in thinking intelligently, critically and creatively in life situations;
- acquire work skills, knowledge and information and a work ethic essential for making an intelligent choice of an occupation and for specialized training in specific occupations; and
- broaden and heighten one's abilities in and appreciation for the arts, the science, and technology as a means for maximizing one's potentials for self-fulfilment and for promoting the welfare of others.

The new curriculum is student-centred and community-oriented. Values are being integrated and designated learning competencies are identified. It is cognitive, affective, and manipulative based. Technology is emphasized in Science and Technology. There is emphasis on critical thinking to promote creativity and productivity. Science and technology subjects emphasize the practical application of scientific facts and concepts. The teaching strategies suggested for the teaching of Science and Technology are the discovery and investigative approaches and the Science Technology Society approach. Innovative/creative activities to encourage imaginative and scientific experimentation and discoveries are suggested. Scientific surveys of the immediate environment and related scientific concepts are encouraged.

To ensure the effectiveness of the new curriculum the materials were developed through a review of the 1973 textbooks and other instructional materials. Competencies for each year level were also validated. These were done with the involvement of

- curriculum writers from the university
- supervisors, teachers and practitioners
- curriculum writers of the Bureau of Secondary Education
- consultants from teacher training institutions, and
- parents and non-government groups.

The curriculum materials were tried out in 80 schools representing 6 types of secondary schools, namely barangay, municipal, provincial, city, vocational, private sectarian and private non-sectarian

The evaluation of tryout classes showed that the new curriculum was more effective than the 1973 Revised Secondary Education Programme. Pilot classes' scores from pre-test to post test increased. Pilot teachers obtained higher mean scores in competency tests than non-pilot teachers.

First year and second year textbooks and teacher's manuals have been printed in time for School Year 1989-1990.

Self Development

The different features of the new curriculum required the training of teachers. These features are the increased emphasis on technology, the new organization of subject, and the setting of desired competencies which must be mastered by teachers and students. Moreover, new strategies have to be learned to teach values education and to promote critical, creative, and analytical thinking.

Training of teachers for the new curriculum followed the scheme used by PRODED which was done by grade level (in SEDP it will be by year level). The training of regional trainers was followed by the mass training of teachers in all regions of the country. In preparation for the mass training of first year teachers, Centres of Excellence (CENTREXES) had been identified to train trainers. One of the CENTREXES is UP-ISMED which handled the training of science and mathematics trainers at all levels. In addition, Regional Leader Schools (RLS) had been identified as centres for the mass training of teachers. Teacher Training Institutions (TTI) were also identified to compliment the RLS. The training design for the mass training were prepared by Regional officers, trainers, RLS and TTI's.

Private schools were involved in the training programmes. FAPE handled the training for the private high school administrators, regional trainers and teachers. The mass training of the private high school teachers would be held simultaneously with the public school teachers. ISMED too was commissioned to train the science and mathematics private school trainers. Private school principals together with public schools principals/supervisors would be oriented on the new curriculum which is being held now at ISMED. However the intended clientele did not come but instead send their teachers for this orientation.

Staff development for the first year level was completed in 1989 which was the start of the implementation of the first year curriculum. Training of trainers and teachers for the second year level is almost completed which prepared the second year teachers for the implementation of the second year curriculum in School Year 1990-1991. The training of third year trainers will be held this May 1990.

The training of trainers and teachers in all year levels and for both public and private school teachers follow the same programme.

Special Features of the Training Programme

Training of Regional Trainers

- One week orientation to values development focusing on personal qualities and using the experiential approach.
- One week for communication skills in English and Filipino.
- Four weeks for content orientation to include an update on content area, strategies and evaluation.

Private Schools

- one month
- Activities cover values development (5 days), technical training (21 days), and action planning (1 day)

Mass Training of First Year Teachers

- Public: 3 days for values development, 3 days for communication skills, and 4 weeks for subject area content to cover subject matter, strategies and evaluation instruments
- Private: 1 day for values orientation and 10 days for subject content, strategies and evaluation.

A complimentary staff development programme was formulated to ensure the effective implementation of the new curriculum. This programme includes the training by selected centres of public and private school Regional Trainers and the mass training of teachers for both public and private high schools. In addition leadership training for secondary school principals/administrators for both public and private schools and fellowship grants on short or long term basis were conducted.

Physical Facilities Development

Research findings of the country's physical facilities and equipment in secondary schools indicated inadequate physical facilities such as classrooms, laboratories, equipment, etc. which contributed to unsatisfactory student performance. There is also inequity and inadequacy in the allocation of resources especially at the local level. Thus there is a need to provide equipment and technical assistance especially for disadvantaged areas.

Provisions for improved physical facilities and equipment for SEDP included the SEDP Building Package. A package consists of a two-storey building including a workshop and a library. The workshop comes equipped with science and work tools. Other expected grants are the 50 typhoon-proof buildings costing $10 M from the Japanese International Cooperation Agency (JICA) and 186 buildings from an United States Agency for International Development (USAID) allotment, and the setting up of the National Fabrication Centre and the distribution centres by the German Government.

Issues in Planning and Implementation

A number of issues will continue to confront the educational system in the remaining years of the 1988-1992 Plan. These are as follows:

Resource generation

This issue is considered to be the biggest challenge to the education sector because of the competing claims of various subsectors on the meagre resources. Additional budgetary support is needed for various activities i.e. full implementation of free secondary education and the financing of the SEDP.

One area where resources for basic education may be tapped is higher education. Expenditures in state colleges and universities (SCU), must be rationalized. The rationale for the proposed solution is that SCUs account for only 23 per cent of the total higher education enrolment and the unit cost per student per year is high. Moreover, SCUs rely on secondary education enrolment for their existence. Other alternatives to make better use of SCUs resources are to allocate SCUs resources to programmes and services which are not provided by the private sectors such as graduate programmes, basic research, etc.

and to work out a mechanism for prioritizing SCUs. Savings generated can be channelled to basic education.

The policy of the integration of private education which makes private education a partner of the government may be implemented. The private sector may serve as a resource which can be used to meet the demands of development.

Necessary adjustments have to be made in education manpower and labour with the limited resource availability. In the light of these limitations, a temporary moratorium in the conversion of barangay high schools into national high schools and of public secondary schools into colleges and universities was proposed. The financial plan for the educational system was drawn by the restructuring of the Special Education Fund, a larger share of the Salary Adjustment Fund, and the education lottery scheme.

Education personnel were encouraged to participate in the national productivity programme such as textbook writing, production of desks, equipment, and items needed by schools. Teachers were given flexible schedules so that all teachers can be engaged in income-generating activities. However, sufficient guidelines will be provided so that the quality of teaching will not be affected.

Increasing mismatch of supply and demand

This issue was brought about by the shift in the skills demands of new industries and technology. Plans, policies and programmes should consistently respond to this issue and influence the country's population characteristics and movements to check the uneven distribution and access to employment opportunities. Linkages between industrial plants and educational institutions must be established. Courses should be made relevant to the needs of industry and improve the employment prospect of graduates.

Difficulties encountered during the implementation were gathered from personal interview with certain trainers and administrators involved in the mass training programmes for the lower secondary level. These were:

- Late arrival of textbooks and teacher's manuals for the training period.
- Lack of projection in the distribution of textbooks and teacher's manuals to region/schools. Not all areas received the books, or if ever they received the books, these were in limited amounts.
- Lack of trained personnel to observe and gather feedback for the mass training programme. In some regions nobody observed in the succeeding (first and second) training periods.
- None or very little background in the Earth Sciences was incorporated in the first year curriculum.
- Lack of equipment in most barangay schools.
- The free secondary education programme created large class sizes, averaging 60-70 students in a class. Cost cutting measures such as the limited hiring of additional teachers had aggravated the problem since teachers were handling 7 to 11 classes. As a result teachers were tired, overloaded and underpaid.
- On the administrator's side, difficulties in scheduling of classes and loading of teachers were encountered. This was brought about by curricular changes like the time allotment given to subject areas. Science is now taught 60 minutes/day while the non-science subjects except Technology and Home Economics are taught 40 minutes/day. This results in the overloading of science teachers compared with the non-science teachers. To solve this problem, the time allotment for non-science subjects was raised to 60 minutes a day.

Science I Curriculum at Secondary Level

The Science I curriculum is exploratory and multi-disciplinary in nature. It is developed around basic principles and concepts of chemistry, physics, biology and the earth sciences. It is intended first to serve as a link from the elementary to secondary science courses and second as an introductory course for the biology, chemistry and physics subjects. Its major objective is to develop technological consciousness and scientific literacy among the students who could assist in nation building. Activities are made more meaningful when scientific concepts and principles are made to connect with student's daily living experiences. The relevance of technology and its products are emphasized. Specific examples of scientific studies mostly about the Philippines in focus are incorporated. For example a scientific study on **tilapia** is discussed in detail to illustrate all steps in the scientific method. Following are excerpts from Science and Technology I textbook.

"When is a study called scientific? A study of tilapia will clarify the meaning of the term scientific. Tilapia, a food fish commonly seen in local markets, has been subject of scientific and technological studies to improve its size, increase its meat content, and speed up its growth to full size. Dr Deogracias Villadolid, a Filipino ichthyologist (a scientist who specializes in the study of fishes), brought the tilapia to the Philippines sometime after World War II.

"Recently a team of ichthyologists in Hadera, Israel, discovered a technique of changing the sex of a population of young tilapia in a container tank to almost all male.... Male tilapia is desired because they grow faster and develop more meat than the females. The process of changing the female to male, known as sex inversion, consists of feeding them on an androgen diet.....

"The sex inversion process is expensive. It requires the use of concrete tanks, large amounts of water, and a supply of food and androgen for the fast-growing tilapia....

One ichthyologist made the hypothesis that sex inversion could be done with much less expense by placing them in a natural body of water such as a river, pond, or lake...

"To try out his hypothesis, he planned an experiment using three cages sunk in a natural pond and one concrete tank filled with water......

(From Cortes, etal, *Integrated Science and Technology for a Better Life I,*
Basic Media Systems, Manilla, 1989)

The Science I curriculum is technology and environmentally oriented. Desired learning competencies are prescribed for First Year Science. The competencies expected of students at the end of the first year science and technology programme are:

I. Introduction to Science and Technology

- Appreciate the contributions to science and technology of outstanding Filipino scientists.
- Demonstrate knowledge of the processes of science in solving simple problems in daily life.
- Appreciate the scientific values of open-mindedness, orderliness, patience and sharing ideas with others.
- Appreciate knowledge of how science and technology affect human beliefs, practices and ways of thinking.

II. Some Forces Around Us

- Demonstrate understanding of force and work.
- Develop skill in measuring forces.
- Appreciate the importance of using standard measuring instruments and units of measure.
- Demonstrate intellectual honesty and accuracy.

III. Investigating Matter

- Demonstrate understanding of the properties, identification and classification of matter.
- Appreciate the use of models to explain the behaviour of matter.
- Demonstrate skills in measuring properties of matter.

IV. Forms and Transformation of Energy

- Demonstrate understanding of energy, its forms and transformation.
- Appreciate the importance of using energy wisely.
- Demonstrate understanding of the energy sources in the Philippines and their uses.
- Demonstrate awareness and understanding of natural events and phenomena made possible by energy transformations and biogeochemical cycles of matter in the environment, and concern for their disruption through human intervention.

V. Changes Occur Naturally

- Demonstrate understanding of physical and chemical changes.
- Demonstrate understanding of the changes occurring in the lithosphere, hydrosphere and atmosphere.
- Understand the implications of physical and chemical changes for the environment and for man.

VI. Living Things and Their Environment

- Understand the interactions of living things with their environment.
- Appreciate how nature maintains balance at the individual, population, community and ecosystem levels or organization.
- Gain understanding of the scientific principals and methodology in preventing environmental degradation.
- Manifest appreciation of man's role in improving, conserving and protecting the environment.

VII. Earth's Place in the Universe

- Demonstrate understanding of the solar system.
- Understand the effects of earth's motion, shape and inclination on time and seasonal changes.
- Appreciate the influence of science and technology on space exploration.

Evaluation of Student Achievement

Quizzes, periodic tests and departmental examinations are mostly cognitive evaluation of student's achievement. These are teacher-made tests which are usually of the objective type. Quizzes may be given daily or weekly. Periodic tests and departmental examinations are given at every grading period (usually every 3 months).

There are no public examinations at the end of the elementary level. A public examination, National College Entrance Examination (NCEE) is given to all students who finish the secondary level of education. This examination is conducted by the National Educational Testing Centre of the Department of Education, Culture and Sports. Students who pass the NCEE can qualify for admission in the institutions of higher learning.

Evaluation of the students behaviour and attitudes are included in the student's report card. These behaviours are punctuality, personal cleanliness and grooming, sociability, cooperation, industry and courtesy are examples which the students may be rated. The ratings are in the form of qualitative descriptions such as poor, good and outstanding.

Practical work are seldom evaluated or not at all. Some teachers may evaluate practical work through the use of pencil and paper test or in the form of laboratory reports submitted to every activity/experiment performed by students. Some teachers are reluctant to accept the different ways of evaluating practical work because of the difficulty of the evaluation instruments and much time consumed because students have to be tested individually.

Teacher Education

In the light of major reforms in the educational system, the Sectoral Action Plan for Manpower Development outlined the main strategy for science and mathematics development at the secondary level. Included in this strategy are the teacher-training programmes.

Two kinds of teacher training on programmes were identified. These were the certificate programmes and the diploma programmes. The certificate programmes are geared for teachers with little or no preparation in the science field they are teaching. This will be offered for two summers or part-time studies over three semesters. The diploma programmes are for teachers who need strengthening or upgrading since they have some preparation in their science fields. These will be offered in all fields and it is hoped that teachers move on from the certificate to diploma programmes. Very few slots are allotted for the master's programme. Major effort of the Plan will be in the certificate and diploma programmes than in the master programme since it has been the experience that teachers who finished the master's programme go into college teaching.

Allotment for the two programmes showed that the certificate programmes are for teachers in physics and chemistry. For the 2 summers about 140 teachers (60 per year in physics and 80 per year in chemistry) will be trained for the first year and 200 teachers for the second year. For the part-time three semester programme, again 140 teachers (60 physics teachers/year and 80 chemistry year) will be trained for the first year. Then for the second year, 200 teachers for the first semester and 140 teachers for the second semester.

For the diploma programmes, a total of 360 teachers will be trained for a year. This is a rough estimate based on the teacher-training institutions capabilities, availability of teachers who can be freed from their schools for one year, and availability of funds. Breakdown of these teachers to be trained are:

Mathematics	=	100 a year
Biology	=	80 a year
Chemistry	=	60 a year
Physics	=	60 a year
Integrated Science	=	60 a year

12. Thailand

The Educational System

The Thai educational system is 6-4-4 (six years at the primary level, three years at the lower secondary level, and three years at the upper secondary level). Educational administration is centralized. All schools throughout the country use the same curriculum authorized by the Ministry of Education.

Compulsory education is six years. At present, about 95 percent of the children in the 6-11 year age group are enrolled in primary schools.

However, secondary education in Thailand is not compulsory. In 1989, about 47 percent of the children in 12-14 year age group were enrolled in the lower secondary level (grades 7-10) and about 38 percent of the 15-17 year age group were enrolled in the upper secondary level. Study at the secondary level depends on the parents' attitude, finance and the student's ability.

Education after the secondary level leads to two types of programmes; the four-year bachelor degree program, and the one to three year diploma programme. There are about 79 institutions which now offer the bachelor's degree. These include 36 teacher colleges, 27 private colleges, 14 public universities and 2 open universities.

Entrance to any public university is very competitive since only about 20-30 percent of the applicants can be accepted. For example, in 1989 the institutions of higher learning accepted only 22,282 out of 93,341 applicants. An entrance examination is the main criteria used to select applicants.

The one to three year programmes are offered in more than 100 institutions. These programmes are aimed at training technicians and skilled workers.

Graduate programmes are offered at most universities. Enrolments in graduate programmes are increasing rapidly.

Science Teaching in the Secondary Schools

There are three levels in the lower secondary education programme M1, M2 and M3 (equivalent to Grades 7, 8 and 9). At present, science is a required subject for all students in all grades and is studied four periods a week. The science course offered is an integrated science rather than separate disciplines such as chemistry, biology or physics.

In 1991, science will be required for only three periods a week for all lower secondary students in all grades. Schools are encouraged to offer more science elective courses. Students may be allowed to select to study science up to 10 periods a week. The elective science courses are more locally oriented. Each school can develop its own science course or can select any other science courses for their students.

It is expected that the study of science, by this approach, will be more locally oriented, and will be more relevant and suitable for the students' interests, needs and abilities.

At upper secondary education (Grade 10-12) students who plan to further their education in science or science related fields would be guided to take discipline science courses such as chemistry, biology and physics up to 10 periods a week for the whole three years.

Students who plan to terminate their studies upon graduation or further their education in fields not related to science are required to take science three periods a week for two years. Physical and Biological Science (PBS) is specially designed for these non-science students. The PBS curriculum is a modular approach and emphasizes more on social issues, the environment, and consumer science. There are 14 independent modules. Students are required to study eight modules in any sequence of four semesters in three years. The fourteen modules are: Solar Energy, Light, Colouring Matter, Electrical Appliances, Invisible Rays, The Earth and Stars, Synthetic Materials, Sound in Everyday Living, Natural Resources and Industry, Good Living, Medicine and Life, Our Body, Evolution, Heredity and Environment.

The Lower Secondary School Science Curriculum Development

One of the most important movements on school science education in the history of Thailand was the establishment of the Institute for the Promotion of Teaching Science and Technology (IPST) in 1972. Many new science curricula have been developed and implemented. The first IPST lower secondary school science curriculum was implemented in 1977 and revised in 1988. The revised curriculum is more technologically oriented. Activities on practical problem solving concerning student's own communities were added. For example problems of hygiene and drinking water for a particular community are posed to a group of students to solve them mentally and practically. Other examples of community problems which are recommended for students to solve are: Soil Quality, Water Quality, Surplus of Agricultural Production in a Particular season, Food Habits Problems of some Minorities, Misuse of Particular Woodland Areas, and problems of Making Fish Sauce in some areas etc.

The Lower secondary school science curriculum is developed by The General Science Design Team which is a division of IPST. The team is made up of classroom teachers, supervisors, teacher college instructors and university lecturers who were recruited as a seconded staff to work part-time with the IPST permanent staff.

The initial decisions concerning the overall organization and philosophies of the new curriculum were made after conducting seminars and after the team completed intensive studies of materials which have already been produced in other countries. The curriculum however, does not follow any particular curriculum from another country. Writers have attempted to develop a Thai-oriented modern science programme for Thai students. The conceptual scheme of science at the lower secondary school level is shown in fig 1.

The lower secondary school science courses are interest motivated and involve students in doing science, identifying problems and looking for methods of solving them. All curriculum materials and activities are designed to enable students to observe their environment, enrich their experiences, and develop skills such as observing, communicating, measuring, hypothesizing and experimenting. Through doing science students gain knowledge of scientific facts and principles and have a better understanding of nature and their environment. The practical experience of doing science also develops students' scientific attitudes in hopes of attaining a rational outlook, open mindedness, persistence, co-operativeness, critical and tolerance of opinions, honesty in presenting observations, etc.

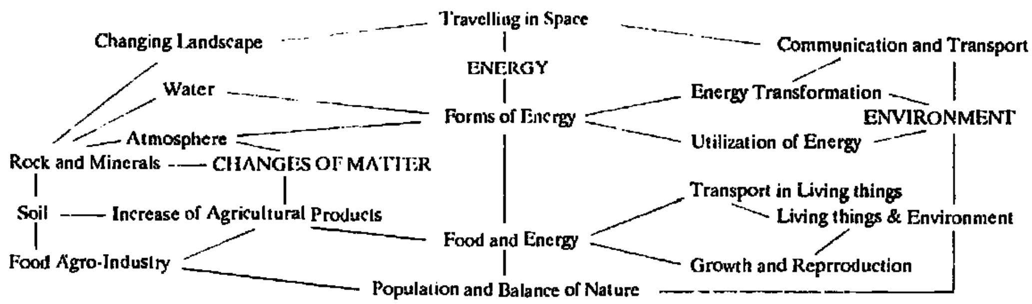


Fig 1. Conceptual Scheme of Science at Lower Secondary Schools in Thailand (Science Education in Secondary School in Thailand, *Dr Nida Sapianchai, former Director of IPST)*

Curriculum Materials:

In curriculum development at IPST, four areas are developed concurrently: the students' books and teachers' guides, the evaluation, the teacher training and the development of equipment. The IPST approach is shown in figure 2.

Students Books and Teachers' Guides:

The former Director of IPST Dr. Nida Sapianchai described the specific characteristics of IPST students' books and teachers' guides as follows:

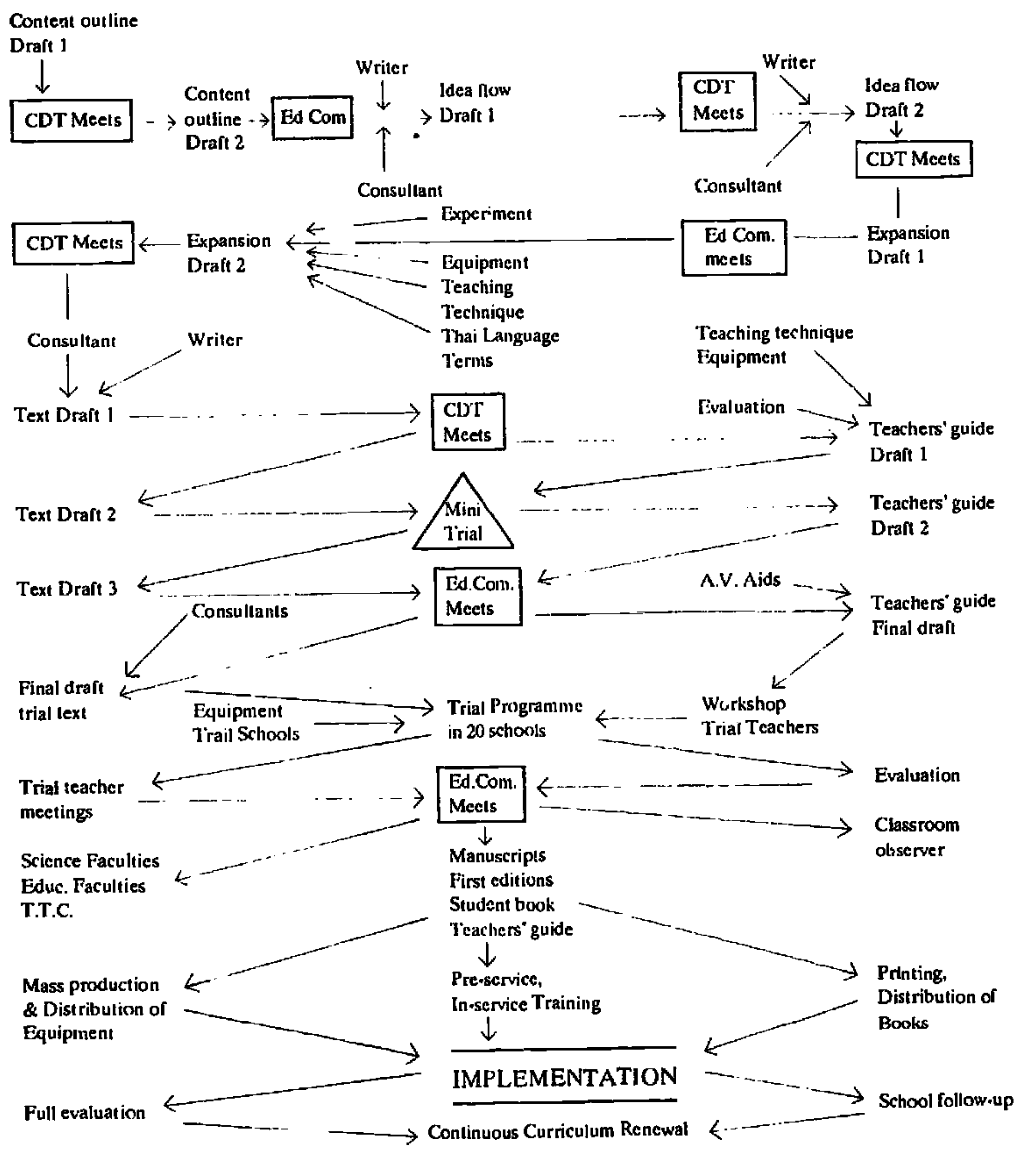
"The students' books contain many activities and experiments around which questions are asked and the students find the answers from observation and from analysis of experimental results. The questions were constructed following analysis of the mental and manual operations required to develop scientific and mathematical concepts. The questions guide the student's learning and place him in the role of the discoverer. The teacher directs the operations, controls the pace and provides assistance when the student or group gets stuck. The teacher also consolidates areas of the subject in more formal presentations. The students' book is not intended to provide the complete story. It is not a text in the traditional sense but a guide to learning."

"The teachers' guides compliment the students' book by providing most of the answers to the questions and by highlighting the important aspects of each section. It gives the teacher additional background material and information on pacing the programme, and on the advance preparation necessary for each experiment. The guides suggest outlines for pre- and post-lab discussions and illustrate how the major concepts in the course might be linked together."

Evaluation

The teachers' guides contain many test items that have been tried in trial schools. It sets out the method of writing items and encourages the teacher to write his/her own items. Teachers are encouraged to assess students' achievements in all three domains namely cognitive, affective, and psychomotor domains.

Fig 2. Development of IPST science curriculum materials



CDT - Curriculum Design Team

Ed.Com - Editorial Committee

The IPST In-service Training Programme

Teachers who would teach the IPST curriculum are the same teachers who formerly taught traditional science. They are familiar with traditional science topics and traditional teaching styles. This creates the most difficult problem in developing the new curriculum at IPST. All curriculum developers at IPST realized that the ... ess of their work depended upon how well they could train these teachers.

IPST has devoted great effort in developing the most efficient in-service training programme within the limitations of budgets, manpower and time. Teachers needed to be trained in many areas: renewal and extension of science content, use of new equipment, management of experiments, and teaching with a new style.

The programme has been developed to ensure that teachers:

- have a sympathetic attitude to the new teaching approach;
- understand the subject matter;
- know how to use the new materials including the visual aids and laboratory equipment.

As part of the programme, IPST adopted a teaching approach which integrated content with method. Instructors use the methods they would like to see teachers use. Teachers, during much of the in-service training programme acted as high school students while instructors acted as high school teachers. With this technique, teachers are expected to learn science content and methods of teaching simultaneously. However a few special lectures on science content, teaching techniques, and evaluation techniques are offered. In addition to these, teachers have opportunities to:

- perform all experiments which they will have to manage in the classroom;
- observe and use videotape, audio slide-tape,audio flimstrip and programmed instruction booklets about the classroom management of experiments, laboratory safety, etc. and
- discuss the IPST philosophy and objectives of science teaching, together with its evaluation.

It could be claimed that the development of this lower secondary school science curriculum was among the most important curriculum developments in Thai educational history. All science content have been carefully selected. It is up-to-date and designed specifically for the Thai society.

The inquiry teaching approach was introduced and teachers were strongly encouraged to use it. Teachers attended 3 - 6 weeks of the IPST in-service teacher training programme at IPST or at the local centres before teaching any IPST courses. The emphasis on the laboratory led the IPST general science design team to search for experiments and to invent new, inexpensive school science equipment which required the use of local materials.

However, 3 - 6 weeks of in-service training did not necessarily mean that all teachers could teach the IPST courses satisfactorily. This was only the beginning. Many teachers still needed help on a more continuous basis.

IPST Science Equipment

Before the establishment of IPST most of the science equipment used in schools were imported. Now 90% are made in Thailand. IPST has its own Equipment Design and Production Team (EDPT) to develop equipment prototypes. In developing science equipment prototypes, the EDPT works in close co-operation with the Curriculum Design Team (CDT). The CDT provides necessary information about the functions of each piece of equipment to be used. EDPT designs and makes equipment prototypes according to the requests using some criteria that each equipment prototype should:

- give results in accordance with the objectives;
- be used easily and safely, and without any complications, and it should provide apparent results;
- be able to be manufactured inside the country using local materials and in country technology;
- be used in more than one experiment, the accessories of one set of equipment can be used with another;
- be kept in the form of a kit, equipment frequently used in the unit should be in the same kit;
- be inexpensive and durable.

The working process of designing and developing science equipment is shown in the following diagram Fig. 3):

CDT provides details about equipment requirements

↓

EDPT makes rough drawings of the equipment
and specifies materials used

↓

Together CDT and EDPT discuss the drawing

↓

EDPT produces 2 - 3 equipment prototypes

↓

CDT and EDPT tries out the equipment prototypes

↓

EDPT produces equipment prototypes
to test in schools

↓

CDT and EDPT do the follow up
of equipment prototypes used in schools

↓

EDPT makes detail drawings of the equipment
and sends them to Ongkanka* for mas production

↓

CDT and EDPT follow up the use of
the equipment in schools throughout the country

Fig 3. The IPST Equipment design and Production Process.
CDT = Curriculum Design Team
EDPT = Equipment Design and Production Team
* Ongkanka is the business section of the Teachers Association of Thailand.

According to the working process,the EDPT does only research and development of science equipment prototypes. The mass production is under the charge of the Ongkanka,a business section of the Teachers Association of Thailand. However the EDPT and Ongkanka work in close co-operation, by having a Co-ordination Committee which meets frequently.

Generally, Ongkanka produces equipment following the design of IPST. However if Ongkanka wants to change the design to be more suitable for mass production, the design can be negotiated with IPST for consideration and permission. EDPT provides academic assistance to Ongkanka especially on quality control.

The EDPT has already designed more than 300 equipment prototypes both for school science and mathematics teaching.

The design of the inexpensive and locally manufactured science equipment not only makes the equipment affordable, but also creates the industry of science equipment production inside the country, using local materials.

Having EDPT working in close co-operation with the Curriculum Design Team provides more flexibility in curriculum development. The Curriculum Design Team can design activities freely since the equipment needed can be developed as desired.

Implementation

The IPST lower secondary school science curriculum was first implemented in 1977 with an intensive follow up programme. The first revision of this curriculum was done in 1988. It was expected before implementation that teaching techniques and budgets for equipment and consumable materials would be two main problems that would face the implementation. The first problem has been solved through the IPST organised in-service training. In addition, elaborate teachers'guides have been produced by IPST to assist the teachers in their teaching. It is also learned from the follow-ups, that these teachers' manuals have been of tremendous help to the teachers.

School budgets for equipment and consumable materials pose a serious problem. To help the schools, the IPST has designed low cost experiments using inexpensive equipment. Students use alcohol burners instead of gas burners, measuring spoons as balances, syringes as measuring cylinders. Every group of three students is provided a student kit which contains basic equipment. The IPST has every reason to be proud of its designing of prototype equipment to lower the production cost and render possible the local production.

The implementation of curriculum in such developing countries as Thailand tells us that teachers are the most important mechanism. The training programmes conducted to help them acquire the necessary skills and confidence, are of utmost importance. In this connection, equipment and teaching materials must be readily available so that the schools can purchase them at reasonable prices. The teaching/learning will never achieve its goal if the whole process relies solely on the teachers inproducing the equipment and materials needed.

Annex

LIST OF PARTICIPANTS

Annex

List of Participants

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The Asia and Pacific Programme of Educational Innovation for Development (APEID) has as its primary goal to contribute to the building of national capabilities for undertaking educational innovations linked to the problems of national development, thereby improving the quality of the people in the Member States.

All projects and activities within the framework of APEID are designed, developed and implemented co-operatively by the participating Member States through nearly 200 national centres which they have associated for this purpose with APEID.

The 29 Member States participating in APEID are Afghanistan, Australia, Bangladesh, Bhutan, China, Democratic People's Republic of Korea, Fiji, India, Indonesia, Iran, Japan, Lao People's Democratic Republic, Malaysia, Maldives, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Samoa, Socialist Republic of Viet Nam, Sri Lanka, Thailand, Tonga, Turkey and Union of Soviet Socialist Republics.

Each country has set up a National Development Group (NDG) to identify and support educational innovations for development within the country and facilitate exchange between countries.

The Asian Centre of Educational Innovation for Development (ACEID), an integral part of the UNESCO Principal Regional Office for Asia and the Pacific in Bangkok, co-ordinates the activities under APEID and assists the Associated Centres (AC) in carrying them out.

In the fourth cycle of APEID (1987-1991), seven programme areas have been selected for the purpose of concentration. These are:

1. Universalization of primary education
2. Continuing education
3. Education and the world of work
4. Restructuring secondary education
5. Educational technology and information technology
6. Training of personnel including professional support services and distance education
7. Science and technology education including science for all.

Science for All and the Quality of Life

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